30.7
n37re
.210
op.2

RESTRICTED
For administrative use only

REPORT ON RESEARCH, SERVICE, AND MARKETING EDUCATIONAL WORK IN THE UNITED STATES DEPARTMENT OF AGRICULTURE

Part II - Chapter 10

Cotton (Including Cottonseed) and Other Fiber Plants

Prepared at the request of the
House Committee on Agriculture
Special Subcommittee
Honorable Stephen Pace, Chairman

United States Department of Agriculture
Washington, D. C.--November 1950

General Comment

The research, service, and marketing educational activities covered herein are reported for the most part on the basis of "work projects," the level at which various U. S. Department of Agriculture agencies keep separate financial records and prepare separate annual progress reports. The statements for these work projects give pertinent information on the nature and purpose of the work being carried on and on the currently active "line projects" which are subdivisions of activity under the broader work projects. They also cover the history and development of the work, the Federal funds (and in a few instances the State funds) expended, some of the accomplishments, and some of the additional work needed in the areas covered by the work project.

Much of the work reported in this and other chapters of the over-all report is conducted in close cooperation with State agencies. While Federal-State cooperation is indicated for all such projects, it has not been feasible to report in detail the extent and nature of such cooperation. Also, except in specific types of work, no effort has been made to indicate the contributions of cooperating State agencies from the standpoint of accomplishments even though in many instances such contributions have been very important.

It should also be pointed out that the material in the over-all report has been organized, as far as possible, for the convenience of members of the Congress, members of commodity and functional advisory committees under the Research and Marketing Act, and others who are especially interested in specific segments of research, service, or marketing educational work.

- - - - - -

Abbreviations of Agency Names

The numbering system used throughout this report includes the initials of the operating agency of the Department conducting or supervising the work.

ARA	Agricultural Research Administration
BAI	Bureau of Animal Industry
BAIC. . . .	Bureau of Agricultural and Industrial Chemistry
BDI	Bureau of Dairy Industry
BEPQ. . . .	Bureau of Entomology and Plant Quarantine
BHNHE . . .	Bureau of Human Nutrition and Home Economics
BPISAE. . .	Bureau of Plant Industry, Soils, and Agricultural Engineering
OES	Office of Experiment Stations
BAE	Bureau of Agricultural Economics
CEA	Commodity Exchange Authority
EXT	Extension Service
FCA	Farm Credit Administration
FS	Forest Service
OFAR.	Office of Foreign Agricultural Relations
OI	Office of Information
PMA	Production and Marketing Administration
SCS	Soil Conservation Service

Table of Contents

FORWARD — Page

COTTON AND COTTONSEED

A - Production

Breeding, Disease Control, Cultural Practices

BPISAE-a-2-1-Cotton breeding and improvement investigations 10-1
BPISAE-a-2-2-Cotton quality investigations 10-6
BPISAE-a-2-3-Cotton disease investigations. 10-10
BPISAE-a-2-4-Cotton culture, nutrition and physiological investigations 10-14
BPISAE-a-2-5-Use of improved seed, and one-variety, etc. . 10-17
BPISAE-Rm:b-526-Facilities for the determination of properties of cotton for breeding 10-22

Insects and Insect Problems

BEPQ-1-f-1-Boll weevil investigations 10-24
BEPQ-1-f-2-Bollworm investigations 10-29
BEPQ-1-f-3-Pink bollworm investigations 10-32
*BEPQ-1-f-4-Cotton aphid investigations 10-36
BEPQ-1-f-6-Plant bug investigations 10-42
BEPQ-1-f-7-Investigations of various cotton insects 10-47
BEPQ-BPISAE-Rm:b-43-Basic research on cotton insects relating to fundamental factors affecting control 10-49
BEPQ-Cotton Insect Survey 10-55

Mechanization and Economics of Production

BAE-a-1-20-Problems of Organization and Operation of Farms (Cotton) 10-58
BAE-a-1-23-Farm Costs and Returns (Cotton) 10-60
BAE-Rm:b 62-Economics of farm mechanization and other improved techniques (cotton production) 10-61
BPISAE-Rm:b-56-Develop efficient equipment for mechanizing cotton production especially on small farms (including defoliation equipment and methods) . 10-64
Cross References 10-67

B - Utilization

Cotton Fiber and Fiber Products

BAIC-RRL-2-3(Part 1)-Cotton fiber utilization investigations 10-68
BAIC-Rm:a-102-Fundamental characteristics of cotton fiber as means of developing entirely new uses 10-88
BAIC-Rm:a-104-Development of new and used products from cotton fiber through processing and chemical treatment 10-93
BHNHE-Rm:a-9-Serviceability studies for the evaluation of family uses of clothing and household fabrics composed of cotton and other fabrics 10-98

Cottonseed and Cottonseed Products

BAIC-RRL-2-3-(Part 2)-Cottonseed utilization investigations. 10-101
BAIC-Rm:a-103-Improvement in methods of cottonseed oil extraction, development of new and improved products from cottonseed and their evaluation . 10-114
Cross References 10-120

* BEPQ-1-f-5-Investigation of cotton fleahopper and related insects 10-39

Page

C - Marketing

Ginning and Associated Processes

BPISAE-e-3-1-Cotton ginning investigations 10-121
BPISAE-RM:a-71 & PMA-RM:c-71-Developing improved equipment and techniques for ginning associated processes 10-125
FCA-RM:c-438-Costs and margins of cotton gins. 10-129
PMA-Improved technology for ginning and associated processes in preparation of cotton & cottonseed for market. . . . 10-148
PMA-Economic aspects of commercial cotton ginning operations 10-151

Marketing Cotton Fiber and Fiber Products

BAE-a-2-7 & RM:c-33-Price, supply and consumption analysis of farm products (cotton). 10-133
BAE-a-2-25 & RM:c-31-Consumer preference studies (textiles). 10-135
BAE-RM:c-163-Measurement of cost and margins of marketing farm products (textiles) 10-138
BAE, PMA, FCA, BPISAE-RM:b-228-Regional marketing of cotton (Including cottonseed) 10-140
PMA-Developing improved practices, facilities, and procedures of marketing raw cotton 10-143
PMA-Marketing practices of cotton mills in procuring cotton of quality needed in relation to quality produced . . 10-146
PMA-Development of improved standards of quality for cotton 10-156
PMA-Relationship of cotton fiber properties and other factors of quality to processing performance, etc. 10-161
PMA-Development of improved equipment and techniques for fiber and spinning testing 10-165
PMA-Cotton testing services 10-169
PMA-Cotton statistics, classing, standards, and futures acts 10-172
PMA-RM:c-70-Improving market outlets for cotton in relation to merchandising procedures. 10-177

Marketing Cottonseed and Cottonseed Products

PMA-Developing improved practices, facilities, and procedures of the marketing of cottonseed 10-154
PMA-Improved standards of quality and methods of grading cottonseed 10-159
PMA-Cottonseed grading service. 10-180
Cross References 10-181

III - OTHER FIBER PLANTS

BPISAE-a-3-1-Hard fiber production, breeding, disease and quality investigations 10-182
BPISAE-a-3-2-Hemp, flax, ramie, urena, crotalaria, and miscellaneous fibers 10-184
BPISAE-e-3-2-Fiber flax harvesting and processing machinery investigations 10-187
BPISAE-e-3-3-Production and processing equipment for special fiber crops 10-189
BPISAE-g-5-1-Research on domestic production of strategic fibers 10-191

FOREWORD

This chapter on cotton, cottonseed, and other plant fibers covers research, service, and marketing educational activities of the USDA concerning these commodities. The part relating to cotton and cottonseed is divided into three major sections--production, utilization, and marketing--which include a description of work on breeding, disease control, cultural practices, insects and insect problems, and mechanization; the utilization of cotton, cottonseed, and their products; ginning and associated processes; and work relating to the marketing of cotton, cottonseed, and their products.

The relatively small amount of work on plant fibers other than cotton is limited mainly to work on production.

Following each major section of the chapter are cross references to project statements in other chapters which include at least some work concerning cotton, cottonseed, and other plant fibers, including some of the work on these commodities that is conducted by State Experiment Stations, State Extension Services, and State Departments of Agriculture and Bureaus of Markets. Attention is also called to Part I of the over-all report, particularly the section of it that summarizes the significance of cotton research and services.

COTTON BREEDING AND IMPROVEMENT INVESTIGATIONS
(BPISAE - No. a-2-1 - Federal-State)

A. Purpose and Nature of Current Work

To develop varieties of cotton which will produce maximum yields of the most desirable qualities under the numerous prevailing and changing conditions as affected by soils, climate, insects, diseases, and cultural and harvesting practices. The current work is particularly concerned with the development of varieties better to meet increased competition from synthetic fibers, paper, and foreign cottons, and which will be better suited to mechanical harvesting. In addition, work of a more fundamental nature is under way to provide new and improved breeding methods and techniques and basic information which will contribute to both a more rapid and a wider range of accomplishments.

B. Currently Active Line Projects

a-2-1-18 - Breeding ~~and~~ for new and extended properties in cottons in the Southeast. To develop cottons with new and extended fiber properties adapted to conditions in the Southeastern Cotton area, that will increase net returns to the farmers and improve mill performance and textile products.

a-2-1-19 - Breeding for new and extended properties in cottons in the Mid-South. To develop cottons with new and extended fiber properties adapted to conditions in the Mid-South, especially the alluvial river bottoms, that will increase net returns to farmers and improve mill performance and textile products.

a-2-1-20 - Breeding for new and extended properties in cottons in the low-rainfall, Blacklands, and Plains areas of Texas and Oklahoma. To develop cottons with new and extended fiber properties better adapted to conditions in the Blacklands and Plains area and to stripper-type mechanized production which will increase net returns to farmers and improve mill performance or end-use products.

a-2-1-21 - Breeding for new and extended properties in cottons in the irrigated areas of the Southwest. To develop improved strains of special and general-purpose upland cottons having new and extended fiber properties adapted to the irrigated valleys of the Southwest which will increase net returns to the grower and more adequately meet the needs of the spinning industry.

a-2-1-22 - Breeding for new and extended properties in American-Egyptian and other extra-long staple cottons adapted to the irrigated Southwest. To develop improved strains of American-Egyptian and extra-long staple upland varieties adapted to the irrigated valleys of the Southwest that will increase net returns to the grower and meet the demands of spinners.

a-2-1-23 - Breeding for new and extended properties and increased returns from Sea Island and other extra-long staple cottons adapted to the Southeast. To develop improved strains of Sea Island and extra-long staple upland varieties adapted to the Southeast that will increase net returns to the grower and meet the demands of users of extra-long or extra-strong staples.

a-2-1-24 - Improving breeding methodology. To develop improved methods for breeding cotton.

a-2-1-25 - Cytogenetics of the genus Gossypium. To determine within the genus Gossypium the number, size, and structure and pairing behavior of the chromosomes as related to cross fertilization and hybridization of cotton species.

a-2-1-26 - Species hybridization and transference of new characters. To obtain new characters and extended properties in American cultivated cottons by transference of genes from wild, primitive, and old world species.

a-2-1-27 - Inheritance of major genes in American upland cotton. To determine the mode of inheritance of the major genes to aid breeders in developing cottons with new and extended properties resistant to disease hazards and which will give maximum net returns to the grower.

a-2-1-28 - Quantitative inheritance in American upland cotton. Separately or in conjunction with line project a-2-1-27 or other projects dealing with breeding for disease resistance, and improvement of yield or fiber quality, to determine the mode of inheritance for important quantitative characters.

C. History and Evolution of This Work

Development of improved cotton varieties was initiated in the early 1900's and was concerned primarily with the evaluation and adaptation of cottons introduced from foreign countries. The rapid spread of the boll weevil focused attention on the breeding of earlier maturing varieties. Later emphasis was shifted to breeding varieties with greater resistance to serious diseases. This was followed by cottons better adapted for irrigation, and of new varieties for the different soil and climatic conditions in the rain-grown areas. Development of fundamental information in genetics of cottons and in fiber technology has permitted the present emphasis on the breeding of high-yielding, disease-resistant varieties better suited for mechanized production and with superior fiber characteristics.

D. Funds--Annual Expenditures

With the cotton work financed from a fund covering work on several crops or lines of work, estimates for early years are difficult to obtain. A very rough estimate of annual expenditures from 1906 to 1929 ranged from $12,000 to $70,000. From 1929 to 1934, the costs approximated $100,000 to $150,000 a year. Since then, the annual expenditure on cotton breeding and genetics has varied from approximately $190,000 in 1934 to $225,000 in fiscal year 1950.

E. Examples of Outstanding Accomplishments

Introduction of Egyptian cotton and the development of the American-Egyptian industry, as it exists today, may be credited directly to Department activities. To date, no Egyptian variety introduced into this country has been found well adapted to our growing conditions. Selection, hybridization, and use of modern breeding techniques have given us American-Egyptian varieties which produce good yields and compete favorably in mill performance with the best Egyptian growths. The two outstanding new American-Egyptian varieties are Amsak and Pima 32.

The development of Fusarium wilt-resistant varieties both in sea island and in upland cottons. From the breeding program which started in the first decade of the century, varieties have been developed that can be grown in every section of the South without serious damage from this disease.

The selection of early-maturing varieties to minimize damage by the boll weevil. The spread of the boll weevil throughout the Cotton Belt in the early years of the present century caused great alarm. To fight the weevil, the Bureau of Plant Industry introduced new types of cotton from Central America and Mexico, where the pest has been native for centuries, and also started a program of selection and hybridization for early blooming types that would mature a crop in a relatively short time. This program succeeded in developing a series of varieties that replaced the older cottons grown throughout the main belt. It was through the efforts of the Bureau and cooperating State agencies that such varieties as Trice, Foster, and Lone Star were developed. These varieties were the foundation stock from which the present improved varieties of the main belt have come, including Stoneville, Deltapine, Coker 100, Empire, and other varieties bred by private and public breeders.

The development of the Acala selections. In introducing new types to combat the boll weevil, some of the cottons introduced from Mexico were soon found to be better adapted to growing conditions under irrigation in the Southwest than varieties grown in the Cotton Belt. The introduction and subsequent breeding work with Acala by the Bureau in California, and cooperatively in New Mexico and Arizona, have resulted in commercial strains of this variety which represent the highest quality in American upland cottons produced in the world. The two outstanding present-day examples are Acala 4-42 and Acala 1517. California last year produced a million and a quarter bales of Acala 4-42. Because of its superior tensile strength and other qualities, this variety was in such demand that none of it went in the loan program.

Development and improvement of methods for breeding varieties and for maintaining the purity and uniformity of the crop that have become standard practice by public and private breeders today. Examples of some of these well-known techniques are the plant-to-row method of selection and the currently used inbreeding techniques.

Improvement of fiber quality. Replacement of the older types was not done without some sacrifice of yield and fiber quality. In the early 1920's, attention was focused on developing cotton an inch or more in length with the yield as high or higher than the shorter stapled varieties then grown. This program succeeded within a period of 15 years. In breeding work conducted cooperatively with agricultural experiment stations, the quality of American upland cottons has been greatly improved since the early thirties. As a result of (1) the regional variety test conducted cooperatively with experiment stations in 14 cotton-growing states from 1935 to 1947, inclusive, and (2) the program in applying fiber and spinning testing techniques to commercial varieties and new strains developed by breeders, many popular varieties of poor fiber quality have been replaced by standard varieties of high fiber quality.

Utilization of wild and Asiatic cottons as germ plasm in cotton breeding. For many years the Bureau of Plant Industry maintained work in the relationship of cotton species. With development of cytology and cytogenetics, the relationship between the wild relatives and the commercial upland types has been worked out. Upland cotton has been found to be tetraploid (i.e., it has twice as many chromosomes as the Asiatic varieties and the wild American relatives). Within the last 12 years it has been possible through the use of a substance known as colchicine to double the chromosome numbers of the wild and Asiatic cottons and to cross them with American upland types. This has opened up a new field, and work is now under way on problems of transferring valuable properties such as fiber strength into upland cottons.

F. Some Additional Research Needed

Development and evaluation of inter-species cottons. Cottons with strikingly different fiber properties, such as strengths 75 percent above commercial varieties, have been discovered through species hybridization--including primitive and wild forms. Potentially these are new textile raw materials. Their rapid development and improvement, particularly increases in yield capacity, are of utmost importance. These preliminary developments could result in basic changes of major significance in the future competitive position of cotton and should be explored fully. As new and extended properties are stabilized, they must be evaluated in each step of processing, finishing, and performance in textile uses.

Development of new and extended properties in extra-long staple cottons. Interest in the production of American-Egyptian cotton has been revived both because of normal peace-time needs and for national security reasons. Every effort is being made to develop an adequate extra-long staple breeding program to meet the competition from synthetic fibers in woven fabrics for which American-Egyptian cottons are suited. There is urgent need to expand the program at Sacaton, Ariz., and to initiate research in New Mexico and West Texas for developing improved varieties adapted to high mountain valleys.

Acceleration of cotton genetics and breeding investigations through production of more than one generation per year. To meet needs for fibers of specific end-use values, and for meeting increasing competition from synthetic fibers, the development of improved cotton varieties should be accelerated. Cottons also must have yielding capacity and resistance to diseases and insects. The cotton breeder must now delay intensive selection for many characteristics until the second and subsequent generations. A location for tropical greenhouses, where segregating generations could be grown for selection during the winter months, would materially speed up the breeding and improvement program.

COTTON QUALITY INVESTIGATIONS
(BPISAE - a-2-2 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To (1) study the fiber properties and evaluate their importance both in spinning performance and in end use; (2) devise accurate and rapid methods of measuring fiber properties; (3) find how favorable changes can be made in fiber properties either by cultural practices or by heredity and thus to improve the quality of cotton. It has been demonstrated that certain fiber properties such as fineness, length, and strength, and combinations of these in a large measure determine spinning value. Variations in these properties are associated with different varieties of cotton and with variations in growth conditions. The current work is largely concerned with the relationship of environmental and varietal factors to fiber properties and use values, and with helping the breeder develop cottons with greatly improved fiber properties.

B. Currently Active Line Projects

a-2-2-1 (Rev.) - Spinning utility and use value of new cotton varieties and strains. To determine the spinning performance of new varieties and strains under different environments, to relate the properties of the cotton in these varieties to their performance in spinning, to the characteristics of the yarns and fabrics and to their value for specific end uses, and to establish the relative importance of the individual fiber properties taken separately and in combination.

a-2-2-3 (Rev.) - Effect of environmental factors on fiber properties. To determine the effect of environmental factors on fiber properties, fiber property inter-relationships, and performance in processing.

a-2-2-9 - Factors influencing yarn appearance as related to hereditary and environmental causes. To determine the influence of fiber properties on yarn appearance, especially neppiness, and to relate differences in yarn appearance to specific genetic and environmentally-influenced fiber properties and to variations in spinning operations.

a-2-2-10 - Mode of inheritance and inter-relationships of measurable fiber properties. To determine for specific fiber properties their mode of inheritance, the nature of their relationships with other fiber properties, and their effects on spinning performance.

a-2-2-11 - Relation between fiber properties and the minute structure of the cotton fiber. To determine the nature of the minute structure of the fiber-wall, factors which modify the structure, and how structural modifications are related to the physical properties and the spinning performance of the cotton fiber.

a-2-2-12 - Fiber perimeter and fiber-wall-thickness as specific components of fiber fineness. To determine the nature and extent of genetic and environmentally induced variations and inter-relationships of the two components of fiber fineness: perimeter and secondary wall thickness.

a-2-2-13 - Influence of heredity and environment on the quality and composition of cotton wax. To determine the nature and extent of the influence of hereditary and environmental factors on the quantity and composition of the wax on cotton fibers. Cotton wax is limited to the surface of the fibers and variations in wax affect the frictional properties of the fibers and therefore spinning performance.

C. History and Evolution of this Work

For many years grade, staple and character have been recognized as factors affecting the spinning performance and use value of cotton. Prior to World War I the only measure of these factors was the judgments of cotton classers. The first concerted efforts to evaluate cotton quality by measuring fiber properties in the laboratory and by studying the inter-relationships of properties as related to spinning performance began in Great Britain in 1920 and in the Bureau of Agricultural Economics in 1925. As knowledge and techniques developed it soon became apparent that all fiber properties vary with the variety of cotton and with the environment during the growth of the plant. Improving fiber quality was soon looked upon as a definite part of the cotton breeding program. This project on cotton quality was begun in 1934 and has continued until the present. The role that many of the fiber properties play in spinning performance has been evaluated and rapid and accurate methods have been devised for measuring length, strength, and fineness. These methods have been used in developing new varieties with improved quality.

D. Funds-- Annual Expenditures

Prior to 1934, practically no money was spent on cotton quality work in the bureau. In 1934 and 1935 approximately $10,000 was expended. This was increased to $39,000 in 1936 and to $52,000 in 1941. In 1950 the allotment was $79,560.

E. Examples of Outstanding Accomplishments

Elimination of varieties having poor fiber qualities. For a time after this project was begun all commonly grown commercial varieties were tested under a wide range of environmental conditions. Certain varieties stood out with superior fiber properties in which others were deficient. Within a few years the poor varieties were replaced and the general quality of the crop was greatly improved. At present all new varieties are thoroughly tested before they are released.

Relationship of fiber properties to spinning performance. Work on this project demonstrated that yarn strength can be attained by increasing fiber strength as well as by increasing staple length. Increased staple length adds to processing costs, therefore the best means of increasing yarn strength is to improve fiber strength. These results have been responsible for the emphasis that is now being placed on fiber strength in the breeding program.

Instruments have been devised to measure length, strength, and fineness quickly and accurately. In cooperation with the Tennessee Agricultural Experiment Station, the fibrograph, a rapid electronic device for measuring fiber length, was developed. This instrument is used today by cotton breeders, cotton merchants and in textile mills whenever a laboratory determination of fiber length is required.

In cooperation with the Tennessee Agricultural Experiment Station, the airflow method was demonstrated to be applicable in measuring fiber fineness and the arealometer was developed using this principle. Instruments using the airflow principle, such as the micronaire and the arealometer, have completely replaced older methods in measuring fiber fineness.

In cooperation with the Arizona Agricultural Experiment Station, the Pressley Strength Tester was developed. This instrument is widely used throughout the cotton industry.

Relation of fiber structure to fiber properties has been investigated; and study of the development of fiber has shown how these structures arise. Environment and heredity have a direct influence on fiber structure, thus affecting fiber properties. A knowledge of structure has provided a sounder basis for improving properties through the breeding program.

Sources of fiber strength have been found in cottons distantly related to commercial uplands, but only relatively minor increases in strength have appeared in a wide survey of commercial types. Therefore, if striking advances in fiber strength are to be made through plant breeding, they must come from wide crosses. The transference of strength through species crosses to upland cottons has been in progress for several years.

F. Some Additional Work Needed

Early evaluation of outstanding cottons having new and extended properties. As new varieties having outstanding properties are developed, they must be evaluated in each step of processing, finishing, and performance in textile uses. The Bureau is now working in cooperation with BAIC, P&MA, and the National Cotton Council in evaluating Hopi Acala 50, a cotton with outstanding yarn strength and yarn appearance that has been multiplied to 300 acres in California in 1950. Hopi Acala cotton is to be tested in more than 25 mills this coming season. As new outstanding cottons are developed similar tests must be run and it will be necessary to work out methods and techniques to evaluate these cottons before placing the seeds in the hands of the farmers.

Development of methods to enable the breeders to select for absence of neppiness in cotton is urgently needed. Neps are small imperfections or knots in cotton which appear at the time of ginning or in the early stages of processing and persist in the finished yarn. At present the only accurate method of evaluating neps is to count them in the card web during standard spinning tests. Although neps can be increased by mishandling, it is clear that nep formation depends upon fiber properties.

Breeders could do much to reduce the neppiness of cotton if they had a method of measuring neppiness on material in their breeding blocks.

Development of rapid methods for measuring fiber perimeters. Fiber fineness is known to be one of the important fiber properties. Variations in fineness are associated with differences in perimeter or differences in wall thickness and these two variables cannot be separated with present rapid methods. It is not possible to tell the difference between a narrow perimeter fiber with a well developed wall and a wide perimeter type with a thin wall. Thin walled fibers are undesirable. A rapid method for measuring fiber perimeter would be of great aid in the breeding program.

COTTON DISEASE INVESTIGATIONS
(BPISAE - a-2-3 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To (1) search for disease-resistant or disease-immune breeding stocks, and in cooperation with breeders and geneticists; (2) incorporate resistance or immunity into new commercially desirable or superior varieties of cotton; (3) study host parasite relationships as an aid to a better understanding of erratic disease behavior under different environmental conditions, and (4) develop testing techniques as an adjunct to screening services to breeders. In cooperation with physiologists, with representatives of responsible chemical concerns, and others to investigate farm practices of value in controlling cotton diseases. To develop or improve methods for the control of bacterial blight, Verticillium wilt, Fusarium wilt, nematode-disease complexes, Phymatotrichum root rot, seedling diseases, and deterioration of cotton fiber in the field before harvest.

B. Currently Active Line Projects

a-2-3-1 - Methods for controlling bacterial blight in upland cotton.

To control bacterial blight, also called angular leaf spot, black arm, and bacterial boll rot by developing blight-resistant upland varieties having superior agronomic and fiber qualities.

a-2-3-2 - Methods for controlling Fusarium wilt of cotton. To devise control measures for use against Fusarium wilt of cotton, investigating such genetic, chemical and cultural-practice techniques as seem to offer promise for this purpose.

a-2-3-3 - Methods for controlling Verticillium wilt in irrigated cotton. To control the hazard caused by Verticillium wilt to production and to fiber quality in cottons of the irrigated region by developing resistant varieties and by devising fertilizer treatments and cultural and cropping practices that are less favorable to the fungus and more favorable to the cotton plant.

a-2-3-5 - Methods for controlling nematodes and nematode-disease complexes in upland cotton. To remove the hazard to cotton production in localized areas in the Coastal Plain and in other areas where nematode damage to upland varieties is severe by developing nematode resistant varieties and through the use of soil fumigant chemicals.

a-2-3-6 - Methods for controlling seedling diseases of cotton. To evaluate the effectiveness of new chemical treatments for preventing fungus damage to cotton seed during the pre-emergence and early post-emergence periods of growth.

a-2-3-8 - Methods for controlling bacterial blight in American-Egyptian and Sea Island cotton. To control angular leaf spot, black arm and bacterial boll rot by developing resistant varieties.

a-2-3-9 - Biological forms and host-parasite relationships of the Fusaria causing wilts of cotton and related plants. To establish the host range of the Fusarium which causes wilt of cotton and to study the fundamental relations between host and parasite in the wilts of cotton and associated plants.

a-2-3-10 - Methods for controlling nematodes and nematode-disease complexes in American-Egyptian and Sea Island cotton. To develop resistance to nematodes and nematode-disease complexes in American-Egyptian and Sea Island cottons by hybridization, testing and selecting, also through the use of soil fumigant chemicals.

a-2-3-11 - Methods for controlling Verticillium in rain-grown cotton. To control the hazard caused by Verticillium wilt to production and to fiber quality in cottons of the Mississippi Delta and other areas where rain-grown cotton is produced, by developing resistant varieties and by devising fertilizer treatments, cultural and cropping practices that are less favorable to the fungus and more favorable for the cotton plant.

a-2-3-12 - Methods for controlling Phymatotrichum root rot. To establish improved methods and techniques in respect to root rot control measures previously demonstrated, using leguminous cover crops and nutritional additions to the soil, and to experiment with new methods and materials that may contribute to root rot control practices.

a-2-3-13 - Methods for controlling field deterioration of cotton fiber. To determine the agents responsible for microbiological fiber deterioration in the field and to investigate genetic, cultural-practice and chemical control methods which may seem applicable. To determine the nature of and methods for controlling non-biological weathering agencies operating on the fiber.

C. History and Evolution of this Work

Investigations of cotton diseases were made by various divisions in the Department of Agriculture prior to the establishment of the Division of Cotton and Other Fiber Crops and Diseases. In 1896 the Chief of the Division of Vegetable Physiology and Pathology listed Fusarium wilt of cotton as one of the principal diseases being investigated. Both Sea Island and upland cottons were ravaged by the disease and attempts were made to find resistance by selection and breeding. Fusarium resistant strains of both Sea Island and upland cotton were developed in the early 1900's. The subsequent spread of cotton production westward, the development and introduction of new varieties, and the appearance of many new and destructive diseases have necessitated increased emphasis on disease research. Since the reorganization of the Cotton Division in 1934 the establishment of cooperative Federal-State working agreements has facilitated intensified research on the disease problems across the entire cotton belt. The widespread and destructive nature of several major cotton diseases and the lack of adequate resistance in many of the new varieties renders it imperative that disease resistance be incorporated in the breeding stocks of high yielding varieties better suited for mechanized production and with superior fiber properties.

D. Funds - Annual Expenditures

The entire research on cotton was originally financed from funds covering several crops or lines of work, therefore accurate estimates of expenditures on disease investigations for early years are difficult to obtain. From 1906 to 1928 the total annual expenditures on cotton probably ranged from $12,000 to $70,000 with additional funds expended by the Division of Vegetable Physiology and Pathology for Dr. Erwin F. Smith's research. From 1928 to 1930 the budget for cotton diseases ranged from $17,000 to $35,000. In addition to the Cotton Division's budget the Bureau of Chemistry and Soils allocated funds to the study of Texas root rot. In 1939 these funds amounting to $27,000 were administered by the Cotton Division as well as $28,000 Cotton Division funds for disease research. Since then the annual expenditures on cotton diseases in the Cotton Division have varied from approximately $43,900 in 1942 to $67,540 in fiscal year 1950.

E. Examples of Outstanding Accomplishments

The development of Fusarium wilt-resistant varieties in Sea Island and in upland cottons. From the disease research program which started in the late 1890's, varieties have been developed that produce satisfactory yields on wilt sick soil. More recent investigations have shown the value of liberal applications of fertilizers high in potash along with the planting of wilt resistant varieties.

Practical Control for Texas Root-rot. The production of a modified soil microflora by tillage practices and leguminous cover crops has minimized losses from root-rot. The best practical control of root rot in the Blacklands area of Texas has been obtained from rotations with hubam clover, where the crop residues are plowed under in late summer or early fall. Early fall plowing (mid to late September) and deep tillage have also proved beneficial in reducing losses from root rot.

Resistance to bacterial blight in upland cotton. Strains of upland cotton have been isolated that are inherently resistant to bacterial blight. This resistance is being transferred by breeding to locally adapted varieties of the entire cotton belt.

Control of seedling diseases and seed borne diseases. Means of obtaining significant increases in yield have been developed through the use of seed protectants to control damping-off and the seed borne diseases during early stages of growth, contributing to a better stand from reduced seeding rates and a conservation of improved seed stocks.

Means of reducing fiber deterioration due to microbial activity in the field. Field deterioration of cotton at the time of boll opening has been found to be markedly reduced by defoliation of the plant.

Control of nematode-disease complex in upland cotton. A high degree of control for nematodes and nematode-disease complexes in upland cotton has been found possible through the use of soil fumigant chemicals.

F. Some Additional Work Needed

Verticillium-tolerant cotton for the entire cotton belt. During the past fifteen years Verticillium wilt has been spreading very rapidly throughout the irrigated Southwest, in the alluvial Mid-South sections, and other rain-belt areas. The disease has now become an alarming hazard to production necessitating the abandonment of upland cottons in some highly productive regions in New Mexico and West Texas. The degree of resistance obtained so far is inadequate to withstand the ravages of the increasingly virulent forms of this disease. Investigations are urgently needed as to the natures of the disease organisms, factors responsible for the spread and increasing severity, and for devising control measures.

Control of fiber deterioration in the field. Fiber deterioration investigations have disclosed numerous important and practical relations of fiber deterioration to defoliation, to anthracnose seedling disease, and to mechanical harvesting, all of which should receive further study.

COTTON CULTURE, NUTRITION, AND PHYSIOLOGICAL INVESTIGATIONS
(BPISAE - a-2-4 Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To (1) determine the influence of nutrients, moisture, and other physical factors, applied chemicals, and biological factors upon growth and development of the cotton plant, upon its adaptability and reproductive capacity and upon quality of products; and (2) determine the influence of these factors upon resistance to disease and upon prevention of deterioration in fiber and seed. Currently, emphasis is being placed on (1) investigation of seed viability in relation to precision machine planting, (2) a re-examination of efficiency of cultural practices, and (3) the manner in which each practice influences fiber properties.

B. Currently Active Line Projects

a-2-4-3 - Influence of environment and applied chemicals on composition and germination behavior of cottonseed. To determine the extent to which desirable seed composition and viability may be improved through production and harvesting practices and how environment and cultural control may modify varietal capacities for composition and vitality of seed.

a-2-4-12 - Growth and fruiting behavior of the cotton plant as influenced by environment and applied chemicals. To advance knowledge concerning all physiological and chemical factors that may be utilized to improve cotton yields, quality of products, and economy of production.

a-2-4-13 - Influence of cultural practices and chemical treatment upon adaptability of cotton to mechanical production and harvesting. To determine the extent to which stand, fertilization, time of planting, irrigation, differential herbicides, insecticides, defoliants and growth regulating chemicals can be employed to better adapt cotton growth and fruiting behavior to mechanized production and harvest.

C. History and Evolution of this Work

Following the spread of the boll weevil, which came into the United States in 1892 and became serious in the Southeast about 1920, it became necessary to adapt varieties to earlier culture in the Southeast and to new and more arid areas as cotton culture expanded toward the weevil-free Western States. Since then continued introduction of new strains has necessitated progressive revision of cultural procedures. During the 1920's U.S.D.A. workers developed the "single stalk" culture method of closely spaced planting to promote earlier fruiting for the purpose of avoiding weevil injury in the Southeast. Depletion of soils by continued cotton culture soon focused attention on deficiency complexes and upon plant diseases that became more severe when nutrient supplies were inadequate or unbalanced. Rapid expansion of the cottonseed crushing industry and attention to purity of planting seed in the early 1900's lent emphasis to research on factors that affected both the viability of seed and the content of oil and protein. During World War II the U.S.D.A. research did much to clarify the exact causes of variation in cottonseed composition. Perfection of fiber property measurements, coupled with clarification of the basic principals of fiber development in the late 1930's (in cooperation with the North Carolina Experiment Station), opened the way for intensive studies of environmental effects on fiber quality. Within the last ten years increased knowledge concerning irrigation, fertilizers and plant populations has stimulated new research on production methods. More recently the advance in use of agricultural chemicals (insecticides, herbicides, defoliants, growth regulations, etc.) coupled with the perfection of cotton production and harvesting machinery has caused a re-exploration of many cultural procedures.

D. Funds - Annual Expenditures

Prior to 1934 cotton physiological research was conducted by several agencies and financed from funds covering several crops and many subject specialty fields. A very rough estimate for this period might be given as: from $3,000 to $25,000 annually. Six thousand dollars was specifically allocated in 1934 and 1935. From 1936 to 1941 the expenditures varied from $63,688 to $65,870. Funds were then gradually decreased during the war years from $46,600 in 1942, to $12,160 in 1946. Allocations to this work increased again during the next four years to $40,089 in 1950. Despite the increasing complexity of cotton physiological problems during the post war years and much higher costs of conducting research, the pre-war allocations for these researches are much less than at the beginning of World War II.

E. Examples of Outstanding Accomplishments

Close spacing was found to increase earliness and retard excessive vegetative growth. This was a very important finding that has become widely accepted and has greatly aided in reducing boll weevil damage in the southeast.

Irrigation investigations over a long period of years demonstrated that more frugal and economic use of water was possible if applications were timed to promote deep rooting during pre-flowering stages, continuous growth during the fruiting period, and limited growth during the ripening period. "Crazy top", a serious limit to production in the irrigated west, was controlled by adjusting time of irrigation so that plants never suffered for water between applications.

Recognition of nutrient requirements in relation to plant disease has led to increased production on some disease infested soils. Replacement of potash in Fusarium wilt-infested soils has permitted the profitable use of locally adapted, improved varieties that are tolerant to this disease.

Biochemical investigations of the nature of resistance to the "Texas Root Rot" disease have demonstrated a biochemical nature of resistance. No cultivated species of cotton was found to include any strains or selections with even partial resistance. Thus, breeding for resistance to this disease was shown to be impractical.

Longevity of cottonseed. Reduction of moisture content of seed to 12% or below during storage has been found essential for seed viability.

Biochemical composition of cotton plants has been found an accurate indicator of certain functions. Defoliation efficiency was found to increase as the starch content of leaves decreased. Low oil content and high protein content of seed result from an inadequate potash supply to plants.

Fabric protection research provided the basic information that was utilized extensively by military agencies during the past war. (This Division conducted most of this work under project a-2-4, but since the results are primarily of pathological significance, they are reported under a-2-3.)

F. Some Additional Work Needed

Investigations of preharvest procedures for preventing field deterioration of open cotton. Preliminary results have demonstrated the value of properly timed defoliation in preventing boll diseases (tight-lock) as well as fiber determination. Investigations of this type should prove very valuable and should include studies of the use of fungicides alone or incorporated with insecticides and/or defoliants.

Biochemical and biophysical influences on fiber properties and yields. There is urgent need for exact methods for evaluating the influences of soil moisture, nutrient, and aerial environment limitations on fiber quality and productivity. Determining tissues and tests that can serve as reliable indicators of maximum efficiencies in the use of fertilizer, irrigation water, defoliants and other practices would provide valuable guides for more precise production methods and lower costs.

FARM USE OF IMPROVED SEED STOCKS, AND ONE-VARIETY COTTON COMMUNITY ORGANIZATION
(BPISAE - a-2-5 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

Variety is the most important single factor in determining the fiber properties and spinning value of cotton. Variety is also a large contributor to yield of lint and seed. Strong competition from synthetic fibers, paper and foreign cottons make it highly important that domestic farmers keep in production only the best varieties plant breeders can develop. As a practical matter of getting the full benefit from the use of superior varieties having high yielding abilities and producing desired qualities of lint, work under this project is designed to help bring about and maintain community standardization upon a given variety along with a workable system of breeder seed increase and distribution in order to avoid mongrelizing and crossing of varieties. In organized one-variety communities member growers agree to follow the latest improved methods of culture and care for their crop and to use improved seed. This helps insure high yield, uniform quality, lower production costs, increased net income, and helps facilitate marketing of large lots of uniform quality cotton.

B. Currently Active Line Projects

a-2-5-1 - Standardized one-variety community production in the Southeastern states. To improve the spinning performance and yield and increase the farm income from cotton produced in the Southeastern states, where many production units are small and fertility of the soil often depleted by numerous years of continuous row cropping, by planting superior high yielding varieties in standardized one-variety communities and adoption of the latest improved methods of culture, harvesting, ginning, and marketing of the crop.

a-2-5-2 - Standardized one-variety community production in the Central Valley states. To improve the spinning performance and yield and increase the farm income from cotton produced in the Central Valley states, with special reference to the alluvial river bottoms of the Mississippi Valley, by encouraging farmers to plant superior high yielding varieties in standardized one-variety communities and to adopt the latest improved methods of culture, harvesting, ginning, and marketing.

a-2-5-3 - Standardized one-variety community production in the Western states. To improve the spinning performance and yield and increase the farm income from cotton produced in the Western states, including the distinctive Blacklands area and the Plains where semi-arid conditions restrict growth and occasional extreme temperatures cause premature development of unadapted varieties, by encouraging farmers to plant superior adapted varieties in standardized one-variety communities and to adopt the latest improved methods of culture, harvesting, ginning, and marketing.

a-2-5-4 - Standardized one-variety community production in the irrigated Southwestern states. To improve the spinning performance and yield and increase the farm income from cotton produced in the irrigated Southwestern states, where Acala strains have been specifically adapted to local conditions such as the high, mountain valleys and the low, hot valleys where the soils are very productive, by encouraging the planting of superior high yielding varieties in standardized one-variety communities and the adoption of the latest improved methods of culture, harvesting, ginning, and marketing of the crop.

C. History and Evolution of the Work

The first publication outlining and recommending cotton improvement on a community basis was issued by the Bureau in 1911 - 40 years ago. In 1920 cotton production made its initial start in the Coachella Valley of California under the direct guidance of this Bureau and while the volume of production was never great, the area has always produced only one variety of cotton.

In 1925 cotton production in the San Joaquin Valley of California was recognized as a new industry and on May 22 of that year the State legislature at the request of leading producers and workers of the Bureau, passed the One-Variety Law naming the variety of cotton (Acala) to be grown in specified counties. Immediately following passage of the One-Variety Law, the Kern County Cottonseed Distributors was created and at once established a working agreement with this Bureau which had research personnel stationed at Shafter. The Bureau was under agreement to breed and maintain the seed stocks and act in a supervisory capacity with the distributors regarding increase and distribution of Acala planting seed to California producers at as near actual cost as possible. This agreement has continued in successful operation for the past 25 years. Today California growers are adequately supplied with varietally pure planting seed at the lowest cost of any area in the cotton states.

In 1931 a one-variety cotton improvement program was started in the old cotton belt states and by 1936 the Experiment Stations and Extension Services in practically all states in the area were working under cooperative agreement with this Bureau to undertake a joint improvement program. Beginning with a small percentage of the acreage in 1931, the one-variety cotton improvement program has enjoyed a steady growth in the old belt. Benefits accrued not only to member growers, but as the program gained recognition and popularity growers who were non-members began to use the same superior varieties. This combined influence has contributed to improvement in the total crop. However, grower members have a distinct advantage by maintenance of a pure seed program and improved contacts for latest research information.

Several plans for a successful seed program have been developed across the cotton belt. In the Southeastern states county production units have been organized to supply planting seed to surrounding areas. In the Central Valley states organized communities use the 1-10-100 plan of increase and distribution to satisfy their own requirements. The Texas Cotton Planting Seed Association through contract growers, produce and distribute a considerable volume of seed. They supply seed of three varieties. The California plan is referred to above. This area has the advantage of high yields of prime seed and only one-variety required.

Participation in the varietal improvement program for the crop year 1949 was reported as 50% of the total acres planted to cotton. Twenty-four hundred communities representing 425,000 growers reported 13,600,000 acres planted to the adopted varieties. Ninety-three percent of the 13.6 million acres was planted to only eight varieties with one of these varieties accounting for approximately 30% of the total acreage.

As new and improved varieties are developed and proven for agronomic and spinning performance, the producers through cooperative work with the State Extension Agencies are advised of their superior values. This is a current and continuing responsibility for research and extension personnel working with agronomic and fiber values of cotton.

D. Funds - Annual Expenditures

Funds used to finance the one-variety project for years prior to 1930 were not specifically allotted. It is difficult to make an estimate of the amount expended, however, it was quite small. For the period 1930 to 1934 the average annual expenditure was about $35,000. Between 1935 and 1939 the expenditure ranged from $26,000 to $40,000. During the 10 year period 1940 to 1949, inclusive, the average annual allotments approximated $90,000 with $83,730 allocated for the fiscal year 1950.

E. Examples of Outstanding Accomplishments

In the following examples several factors contribute to the accomplishments cited. However, breeding and community utilization of superior varieties are unmistakably the major items producing the added value.

Value increases of $12.50 per bale to producers in South Mississippi during the period 1931-1936 is recognized as a direct effect of a one-variety improvement program initiated under this project and conducted jointly with the State Extension Service. In 1931 when the program was begun, the local cotton was short, non-uniform, and often difficult to sell. Producers in the territory getting a price of 150 points Off were topping the market. A large percentage of producers in this local area accepted the same variety. By 1936 the growth had changed from very short to a staple length of 1" plus and the going price in the local market was 100 points On. Growers in this area had not only improved their local market structure by $12.50 a bale but had the added advantage of increased yields and other added values on account of the wide acceptance of an improved variety as well as a plan for maintaining planting seed.

Before this program was begun cotton was rarely sold except by submission of actual samples to the buyer. However, after the same variety was widely grown in the area many transactions were made by grade description because the uniformity of staple could be accepted by the buyer. This situation became quite general in many localities where serious effort towards varietal improvement was undertaken. Then, too, many cotton merchants were informing themselves as to where growers were improving their cotton and would alert their local buyers to become active in those markets.

Two hundred and sixty million dollars added to the crops of 1938 to 1945, inclusive by the one-variety program. State personnel cooperating with the one-variety program in the old belt have estimated an additional value to growers from increased lint and quality by the use of improved varieties and good seed stocks for the period 1938-1945, inclusive to be $260,000,000. This was the period where improvement was the most rapid with yield and quality differences significant between member and non-member growers.

Staple length of U. S. Crop changed from 74% Shorter than 1" to 72% 1" and longer in approximately 15 years. These figures express the difference by comparison of the average growth of the crops of 1929-1933 with average crops for the years 1945-1949. This change in the staple length of the entire U. S. crop represents an enormous money value and is reflected to the producers in increased income and to the textile industry in improvement in quality. The period covered by this major improvement in fiber quality coincides significantly with the development of the one-variety program supported under this project and by cooperating State Agencies.

One and a quarter million bales of varietally pure Acala 4-42 produced in the San Joaquin Valley in 1949, can be credited to a considerable degree to activities under this project. The largest cotton merchant in the world has described Acala 4-42 as one of the "outstanding cottons of the world grown under irrigation". Without a working agreement such as exists between this Bureau and California Planting Cotton Seed Distributors, an organization created and incorporated to increase and distribute cotton planting seed bred and maintained by this Bureau without profit, it is doubtful if this new and superior strain could have been disseminated to the entire valley in so short a time. The cost of breeding, improving, and distributing seed of this new cotton has been negligible in comparison to the financial returns to growers and the benefits to the textile industry on account of improved quality.

F. Some Additional Work Needed

Procedure to have available for the textile industry sustained supplies of varietally pure cotton. In view of biological, engineering and fiber technology developed in the last decade, the production and consumption of raw cotton is entering a new era. Varieties with greatly improved fiber properties are now in the process of development and adoption. Without a well defined seed increase program and a distribution system organized to deliver large lots of these new cottons varietally pure to the spinner, maximum benefits will not be achieved. The one-variety program with refinements such as bale identification with its necessary safeguards is an effective method of doing this on an industry-wide basis.

EVALUATE METHODS AND EQUIPMENT, AND ESTABLISH FACILITIES FOR THE DETERMINATION OF FIBER AND SPINNING PROPERTIES OF COTTON EARLY IN THE BREEDING PROGRAM TO EXPEDITE THE DEVELOPMENT OF IMPROVED VARIETIES

(BPISAE - RM:b-526 Federal-State - RMA Funds)

A. Purpose and Nature of The Work

(1) To evaluate methods and equipment and establish facilities for the determination of fiber and spinning properties of cotton early in the breeding program, and (2) expedite the development of improved varieties. The current work is chiefly concerned with the development of small scale spinning tests which will enable the breeders to test their outstanding lines in the progeny row stage.

B. Currently Active Line Projects

RM:b-526:1 - Development of small scale spinning tests. To develop and standardize spinning procedures using small scale equipment and to develop appropriate sampling procedures and testing techniques for evaluating the spinning performance of small lots of cotton.

RM:b-526:2 - Early evaluation of breeders material. To obtain by means of small scale spinning tests an early evaluation of the spinning performance of progenies developed in the breeding program.

C. History and Evolution of This Work

Small scale spinning techniques using less than 1 pound of cotton have been developed in Great Britain, Egypt, and India, but have not been previously used in this country. Spinning tests developed by PMA may be made on a minimum of 2 pounds of lint, but are usually run on 5 pounds. This means that breeders must wait two years from an original selection before it is possible to subject the cotton to spinning tests. With small scale spinning techniques it is possible to obtain a spinning evaluation of any cotton the first year after selection.

This project was approved in August, 1949 and following this a trip was made to England to study small scale spinning in operation. The first year's funds were used chiefly to buy equipment to set up the laboratory.

D. Funds - Annual Expenditures

During the first year, 1950, $25,000 was expended on this project.

E. Examples of Outstanding Accomplishments

The project has not been in operation long enough to have any outstanding accomplishments.

F. Some Additional Work Needed

Evaluation of environmental effect on fiber properties by the use of small scale spinning tests. It has not been possible to make many basic scientific studies on the effect of environment on the spinning performance of cotton. The expense of having controlled samples of a large enough magnitude plus the expense of the spinning tests have made these studies prohibitive. With small scale techniques such basic studies could be pursued without undue expense and should be of fundamental importance in understanding the effect that different environmental factors and combinations of factors have on spinning performance. Other additional research on this project should await further developments in the work that has just begun.

(For work in cooperation with States on regional projects S-1 and S-2, see Chapter 39.)

BOLL WEEVIL INVESTIGATIONS
(BEPQ - No. I-f-1 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To develop methods for the control of the boll weevil, which is the most important insect that affects the cotton crop in the United States. (This pest often reduces the crop by 7 to 10 percent. In certain years in some States it has reduced yields from 25 to 45% and on many farms the yields have been reduced from 75% to 95%.) Emphasis is currently being placed on the development in the field of new toxicants that show promise of being effective against this pest, particularly on determining the proper time of application, intervals between applications, and minimum concentrations of insecticides required for control at different stages of cotton growth, proper dust or spray formulations, and proper methods of their application. The relationship of boll weevil control to the populations of other insects is being studied as are methods of boll weevil controls which will not result in an increase of other injurious pests or which will control them simultaneously with the boll weevil.

B. Currently Active Line Projects

I-f-1-1 - Survey of boll weevil distribution, abundance and damage. To survey boll weevil populations in the field and to correlate and interpret such data in relation to climatic conditions which might be helpful in predicting boll weevil outbreaks, then to provide timely information to farmers, county agents, extension entomologists, the insecticide industry, and the public, regarding the current status of the boll weevil as an aid in planning control programs and the orderly distribution of insecticides.

I-f-1-2 - Early fall cutting of cotton stalks for boll weevil control. To determine the extent that early fall cutting of cotton stalks results in lowered boll weevil populations and subsequently less injury in cotton fields during the following year, and to study this method in relation to other agronomic practices which might result in increased cotton yields.

I-f-1-3 - Chemical defoliation of cotton for boll weevil control. To determine in different areas the extent that chemical defoliation of cotton in the fall reduces boll weevil injury to the succeeding cotton crop and the relationship of this practice to the mechanical harvesting and overall economy in cotton production.

I-f-1-5 - Insecticide tests in field plots. To make comparative tests under field conditions in four States of promising insecticides or combinations of insecticides in an effort to determine those which will provide the most practical and economical boll weevil control.

I-f-1-6 - Conservation and soil improving practices, including strip farming, and their effects on boll weevil damage. To determine the extent to which conservation and soil improving practices influence boll weevil abundance and damage.

I-f-1-7 - Hibernation and survival in cages and under natural conditions in woods trash. To ascertain the comparative survival of boll weevils in cages and in nature and to correlate this with climatic conditions to provide information in March, April, and May regarding the probable boll weevil outlook for any given year in the counties where the studies are made.

I-f-1-8 - Chemical and physical qualities of insecticides, and their effect on toxicity to insects and plants. To develop insecticides possessing a high degree of toxic action against the boll weevil and other insects, with desirable physical qualities for ease of application either as dusts or as sprays. The insecticides must not cause injury to the cotton plant, and with ordinary precautions must not be detrimental to the health of man or to livestock.

I-f-1-9 - Comparative losses caused by the boll weevil. To determine the comparative reduction from full yield caused by the boll weevil in various locations, and under different climatic conditions, from year to year and to correlate these losses with gains that result from approved practices used for boll weevil control.

I-f-1-10 - Combination insecticides for control of boll weevil and other insects at the same time. To develop a combination of insecticides that will at the same time effectively and economically control all cotton insects and mites.

I-f-1-11 - Varietal resistance to boll weevil damage. To assist plant breeders to develop highly productive varieties of cotton with characteristics which are unfavorable to boll weevil attack by extensive testing of available varieties of cotton against boll weevil infestation.

C. History and Evolution of this Work

The boll weevil, a Mexican insect, was discovered in the United States in 1892 near Brownsville, Texas. It was called to the attention of the Department of Agriculture in 1894 and entomologists were sent to the infested area to investigate it that year. Studies made during 1894 and 1895 revealed the seriousness of the situation and in 1896 Congress made a special appropriation to provide for more intensive investigations. Department entomologists that year recommended the establishment of a non-cotton zone in south Texas to prevent its further spread but this was thought inadvisable by the State concerned. All investigations on the boll weevil from 1897 to 1900 were conducted by the State of Texas. The boll weevil continued to spread in the United States and in 1901 Texas again requested assistance from the Department in combatting it. Department entomologists have been actively studying the problem since that time. A research laboratory was established at Victoria, Texas, in 1902. Intensive studies were made during the next 10 years on the biology and control of the boll weevil as it continued to spread northward and eastward. It was soon discovered that early fall destruction of cotton stalks and the use of chain cultivators to drag punctured squares from under the shade of the plants and deposit them in the center of the row exposed to the sun, afforded some control. A laboratory was established at Tallulah, Louisiana, in 1909 and it was there that the use of calcium arsenate dust for boll weevil control was developed and released in 1916. This insecticide became the standard for boll weevil control from 1918 until 1947 and in 1950 is still used extensively. Serious drawbacks to its use included an increase in cotton aphids that often cause serious damage following successive applications, injury to light sandy soils after several applications, and at times an increase in bollworm damage. Following World War II several chemicals were developed that are highly effective against the boll weevil and at least four of them are now being widely used for boll weevil control. Experiments are being continued with these and other new insecticides in an effort to find one or more that will effectively and economically control the boll weevil, as well as associated insects.

D. Funds - Annual Expenditures

The first Federal appropriation for boll weevil investigations was $2,000 in 1896. From 1897 to 1900, inclusive, no Federal funds were appropriated, and from 1901 to 1903, $2,000 was appropriated annually. From 1904 to 1922 the average annual expenditure was $40,791, ranging from $10,145 in 1909 to $84,282 in 1922. The average from 1923 to 1932 was $154,473 and from 1933 to 1950 $48,340. In 1950 $44,000 was spent on boll weevil investigations. The total amount spent by the Federal Government on boll weevil investigations during the 58 years since this pest entered the United States amounts to $3,207,897. This compares with a conservative estimate of $200,000,000 average loss caused to the cotton crop by this insect each year during the past 50 years.

E. Examples of Outstanding Accomplishments

Biological studies provide basis for control. The extensive study of the life history, habits and ecology of the boll weevil is an outstanding accomplishment and is the basis for all control practices developed for use against the boll weevil.

Stalk destruction method developed for weevil control. The discovery that the early fall destruction of the cotton stalks is an effective and practical method of reducing the boll weevil from cotton fields the following spring has for many years been of great value in boll weevil control.

Development of certain cultural and other farm practices that aid greatly in cotton production in spite of heavy boll weevil infestation. The following practices are highly beneficial to cotton farmers: (1) early planting of rapid-fruiting, early-maturing, high yielding varieties of cotton; (2) close spacing of rows and of the cotton plants; (3) the proper soil preparation for best results in getting early stands and rapid growth in each area; (4) the use of fertilizers in many areas; and (5) frequent shallow cultivation.

Hibernation quarters of weevil discovered. The discovery that weevils pass the winter successfully under leaves and trash in woods adjacent to cotton fields is a material aid in the fight against the boll weevil. This research indicated how to select fields to avoid heavy weevil injury, as well as the value of winter cleanup of favorable hibernating quarters to reduce weevil populations the following spring.

Natural control factors found preventing weevil damage during certain seasons. High summer and low winter temperatures, several dozen species of parasitic and predacious insects, and other natural factors, were demonstrated to reduce weevil populations greatly in many areas.

Calcium arsenate developed as boll weevil killer. The development of calcium arsenate as an insecticide for the control of the boll weevil kept cotton production profitable and kept alive the South's major source of income - the production of cotton - at a time when in many areas this crop was threatened with extinction because of the boll weevil.

First use of airplanes for boll weevil control. The first practical use of aircraft for insect control purposes was accomplished at Tallulah, Louisiana, in 1922. Cotton dusting by airplane has been a major commercial industry for nearly 25 years, and this is based directly on developments made in early cotton insect control investigations.

Dusting equipment developed for boll weevil control. The development of ground and airplane dusting equipment for the application of insecticides for boll weevil control has aided the development of similar equipment used in applying insecticides to other field crops.

All-purpose cotton insecticides developed. Combinations of two or more insecticides to control boll weevil, cotton aphid and bollworm simultaneously contribute greatly to lowering the cost of cotton production and improving its quality at a time when competition from foreign countries and the development of synthetic fibers seriously threatened the industry in the United States.

Insecticides discovered that kill weevils inside cotton squares. The discovery that a new organic insecticide kills boll weevils developing inside of punctured cotton squares opens up an entirely new approach to cotton insect control. Plant tissues absorb this insecticide and kills insects developing within these tissues. The economic value of this discovery has not yet been fully determined. Laboratory tests of such chemicals are now conducted under RM:b-43.

F. Some Additional Work Needed

Boll weevil control investigations should be conducted in all important cotton growing areas where this insect is a serious pest. The boll weevil is nearly always a serious pest in 11 or 12 of the leading cotton growing States. At times it reaches the cotton growing areas of four other States. It is important to have adequate knowledge of the boll weevil and its control in all areas of the country and under all kinds of conditions where it occurs.

New Insecticides. Tests with promising new chemicals must be continued to develop more effective, economical and safer insecticides than those now available for boll weevil control. Additional small plot and large scale field tests are needed. New chemicals that show promise of effectively controlling the boll weevil must be evaluated so that farmers can be advised concerning the relative merits of the different materials available to them and given the choice of the cheapest, most effective means of control.

Coverage on boll weevil hibernation, survival and emergence surveys should be more adequate. Studies on these subjects have been conducted chiefly at two field laboratories, one in South Carolina, and the other in Louisiana. The farmers, county agents, and the cotton and insecticide industries in all the States where the weevil occurs demand information about prospective boll weevil survival and emergence as soon as possible. These studies should be conducted in many areas including at least one locality in each of the 12 important cotton growing States where the boll weevil occurs.

Boll weevil studies needed in relation to new cultrual and agronomic practices. Research is continuously bringing about changes and improvements in the cultrual and agronomic practices related to cotton production. Some of these changes undoubtedly affect the boll weevil populations and the amount of damage caused by this insect. Studies must be conducted to determine how the effective control of the boll weevil is obtained by changes or improvements in mechanization and of new varieties of cotton, rotation and soil conservation practices, chemical defoliation of cotton, and the early fall destruction of the cotton stalks.

BOLLWORM INVESTIGATIONS
(BEPQ - No. I-f-2 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To develop methods for the control of the bollworm. This insect sometimes causes losses of from 25 to 75 percent of the crop over wide areas. Work currently in progress is designed primarily to determine which of the newer insecticides are effective against this insect, proper concentrations, formulations and rates of application, and proper timing of applications of these. Control measures used against other cotton insects, particularly the boll weevil, often reduce the natural enemies of the bollworm, which greatly aggravates the situation, therefore research is also conducted to determine this relationship.

B. Currently Active Line Projects

I-f-2-1 - Alternate host plants of the bollworm and their relation to infestations of cotton. To determine the various alternate host plants of the bollworm, their seasonal and geographical distribution throughout the Cotton Belt, and the relation that they may have to the damage caused to cotton by the bollworm.

I-f-2-2 - Strip cropping and conservation practices - relation of increased use on bollworm damage to cotton. To determine the effects that strip cropping and other soil conservation practices have on the amount of damage caused to cotton by the bollworm.

I-f-2-4 - Insecticide tests in plots or fields for bollworm control. To develop practical and economical insecticides for the control of the bollworm on cotton.

I-f-2-5 - Timing insecticide applications for use by farmers. To develop practical methods which can be used by farmers in determining when to begin applying insecticides for the control of the bollworm.

I-f-2-6 - Ecological factors which contribute to control and which influence winter survival and time of emergence. To determine the relative importance of various ecological factors on winter survival, time of emergence and control of the bollworm.

I-f-2-7 - Natural enemies, their importance and effect on the bollworm and their relation to aphid buildup and the use of insecticides. To determine the extent to which native parasites and predators attack the bollworm; to determine the extent to which insecticides affect the parasites and predators, either by killing them off or by inducing aphids or other insects on which the parasites and predators may center their attack instead of on the bollworm.

C. History and Evolution of this Work

The earliest record of the occurrence of the bollworm as a pest of cotton in the United States was in 1820. By 1841 it was one of two insects then considered serious pests of the cotton crop. It still causes serious injury to cotton in some areas of the Cotton Belt each year. The bollworm is practically world-wide in distribution, and it attacks a wide variety of host plants, in addition to cotton. There are from 4 to 6 generations of this insect annually in the south. Usually the second and third generations occur on corn but as this crop matures the moths deposit their eggs on cotton. It is usually the fourth and fifth generations that cause serious injury to cotton. Early research on the control of this pest first started in the Department in 1878 largely concerned cultural practices, since life-history studies indicated that cultural methods of control might be practical. Other control measures studied at this time included the use of sweetened baits, light traps, trap crops, early planting, and "topping" the cotton plants. Early research on chemical control included paris green, london purple, and arseante of lead. Paris green was recommended as a control measure as early as 1905. With the discovery of the effectiveness of calcium arsenate and its development as an insecticide against the boll weevil, tests were made to determine the effectiveness of this chemical for bollworm control. Hundreds of other chemicals were tested against the bollworm during this period but only a few showed any promise. When the remarkable insecticidal qualities of DDT were discovered and this material became available in sufficient quantities in this country for experimental use in 1944, studies were made of its effectiveness against the bollworm. Many other organic chemicals have been tested against the bollworm since and some of the new ones now under investigation show promise of being even more effective and more economical for farmer use than any yet used.

D. Funds - Annual Expenditures

No direct funds were available for bollworm research until 1922. As early as 1878, small amounts were made available for research on cotton insects; about $500 was directed to bollworm that year. From 1904 until 1910, about $7,500 was used annually for research on this pest from funds available for cotton insect research. Federal funds directed to bollworm research were from $700 in 1924 to $20,000 in 1932, and have averaged about $10,800. The amount spent during 1950 was $15,876.

E. Examples of Outstanding Accomplishments

Cultural control methods developed for bollworm control. The development of cultural methods of control as a result of early research on this insect kept the cotton industry alive in the late 1800's and did much to make the economical production of cotton profitable. These researches today are the basis for many recommended farming practices which help keep the bollworm in check.

Use of arsenicals discovered for bollworm control. The discovery in the early 1900's that paris green could be used effectively to supplement cultural methods of bollworm control, combined with the later discovery in the 1920's of the value of calcium arsenate for the control of this insect were notable research achievements.

Value of DDT for bollworm control discovered. This, and the development of combination insecticides for the simultaneous control of the boll weevil, bollworm, cotton aphid and red spider mite, mark the greatest single advance made thus far in the effective and economical control of the bollworm and other cotton pests.

F. Some Additional Work Needed

All species of "bollworms" need to be studied. In the light of the recent discovery that the insect commonly known as the tobacco budworm is probably of more actual importance as a destroyer of squares and bolls than the bollworm, particularly in the southeastern States, and that certain other species of insects contribute greatly to the total amount of "bollworm" damage, additional research is urgently needed on the seasonal and geographical distribution and abundance, host plant relationships and control of these pests.

Since "bollworms" are the most difficult of all cotton pests to control and since effective control is dependent on timeliness of application of insecticides, additional research is needed with particular emphasis on this point for each of the species of so-called "bollworms."

Additional research is urgently needed to determine complexities which occur when the control of one or more insects create conditions favorable for the rapid increase and subsequent injury by other possibly more serious pests. The application of insecticides for the control of the boll weevil and other cotton pests, often aggravates the bollworm problem by destroying its predators and parasites. An aphid outbreak results which attracts moths to cotton plants to feed on "honeydew" secreted by the aphids. This condition is aggravated by widespread use of certain of the new organic insecticides.

Search should be continued under this and related projects for an insecticide, or a combination of insecticides, that will effectively and economically control all cotton insect pests without creating other hazards.

PINK BOLLWORM INVESTIGATIONS
(BEPQ - No. I-f-3 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of these investigations is to develop methods for the control of the pink bollworm. This insect is by far the most devastating cotton pest now known where it occurs. It destroys fully 60 percent of the cotton crop in some areas of the world. Current work is concerned primarily with determining (1) the effects of such cultural practices as (a) early planting, (b) early fall destruction of cotton stalks, (c) early chemical defoliation of cotton, (d) fall and winter plowing, (e) irrigation, and (f) the use of new and improved varieties of cotton, on the pink bollworm population and subsequent injury caused by it to the cotton crop; with (2) laboratory and field tests using various insecticides and combinations of insecticides to find those that are highly effective and economical for use in pink bollworm control; and (3) with hibernation experiments at various locations in the infested territory to study the effect of winter temperatures and other ecological factors on the pink bollworm under various conditions of hibernation, such as (a) direct exposure on the plants under field conditions, as (b) debris left on the surface of the soil, (c) in bolls buried at different depths in the soil and not irrigated, and (d) in bolls buried at different depths in the soil and irrigated at different intervals.

B. Currently Active Line Projects

I-f-3-1 - Insecticides for pink bollworm control. To find the most effective insecticides for practical use in pink bollworm control; to obtain information on the formulation, interval of application, rate of application, time of application, and method of application for maximum results with each insecticide.

I-f-3-2 - Natural enemies of the pink bollworm. Establish natural enemies of the pink bollworm in the areas where this insect occurs in the hope that some increase in degree of natural control will result; determine the native parasites and predators of the pink bollworm and develop or increase their numbers and effectiveness.

I-f-3-3 - Plowing, irrigation and other cultural practices for increasing the mortality of hibernating pink bollworms. To determine the effective cultural practices for reducing pink bollworm carryover from one crop season to the next.

I-f-3-4 - Susceptibility of different varieties of cotton to pink bollworm attack. To find the varieties of cotton most suitable for growing under pink bollworm conditions wherever this insect occurs.

I-f-3-5 - Cultural practices, including spacing used by farmers, and their relation to pink bollworm population and damage. To determine the effects of spacing and other cultural practices used by the farmers on pink bollworm abundance.

I-f-3-6 - Investigations to determine the number of pink bollworms hibernating in the crop debris and soil, and the factors influencing their abundance. To determine the number of pink bollworms hibernating in the crop residue and in free cocoons in the soil as well as the winter survival in the two types of material.

I-f-3-7 - Seasonal abundance and distribution of the pink bollworm as indicated by bloom, boll, and gin trash inspections. To determine the seasonal status of the pink bollworm infestation.

I-f-3-8 - Field cleanup: Investigations of the date and method of cleanup and the number of pink bollworms remaining in the fields. To determine the most effective dates and methods of cleaning up the fields for reducing the carryover of pink bollworm from one crop season to the next in each region where this insect occurs.

I-f-3-9 - Hibernation, winter survival and time of moth emergence under different climatic conditions. To study the effects of environment and seasonal conditions on pink bollworm survival and time of moth emergence.

I-f-3-10 - Alternate host plants of the pink bollworm and their importance in the perpetuation and spread of this insect. To determine the importance of secondary host plants in perpetuating the pink bollworm.

I-f-3-11 - Chemical defoliation of cotton as a means of reducing pink bollworm population. To study the effectiveness of chemical defoliation as a means of suppressing the pink bollworm.

I-f-3-12 - Chemical control of overwintering larvae in crop debris and soil. To test the value of various chemicals in reducing the overwintering pink bollworm populations.

C. History and Evolution of This Work

The pink bollworm was introduced onto the American Continent presumably through cotton seed shipped from Egypt to Mexico in 1911. This seed was first planted in the vicinity of Monterey, Mexico, and seed from this planting, presumably infested with pink bollworms, was taken to the Laguna District of North-Central Mexico for further plantings. The pink bollworm was first actually identified from cotton grown from these seed in the Laguna in 1916. This discovery caused great alarm on the part of both Mexican and United States Officials because the insect was known to be a very serious pest of cotton in Egypt and in India. It was first discovered in the United States in the vicinity of Hearne, Beaumont, and Anahuac, Texas, in 1917. Late in the following year it was found in the cotton producing areas of the Big Bend and in the Pecos Valley. Following the 1917 discovery of this insect in the United States, the need for immediate research was recognized by the Department and a research laboratory was established in cooperation with the Mexican Government near San Pedro in the Laguna District, Mexico. Investigations on the life-history and habits of this insect, cultural and insecticidal methods of its control, its host-plant relationship, and the possibility of control by natural enemies were conducted at this laboratory until 1927. The research work of the Department on the pink bollworm was transferred from Mexico to the United States with headquarters at El Paso, Texas, in 1927, and at Presidio, Texas, in 1933, where investigations on life-history, habits, cultural and insecticidal control, varietal resistance, and control by native and introduced parasites have been conducted. Part of the research work was transferred to the lower Rio Grande Valley in 1939 and present headquarters for research are at Brownsville, Texas. Through the efforts of the Federal Horticultural Board up to 1926, and the Bureau of Entomology and Plant Quarantine since that time, the spread of this insect to the main cotton producing areas has been held in check. Infestations have been found in isolated areas of Louisiana, Florida, Georgia, Oklahoma, New Mexico and Arizona, and it has spread to several other areas in Texas, but these infestations were eradicated through control operations developed as a result of research. The pink bollworm is known now to occur in the United States only in limited areas in Texas and New Mexico, and on wild cotton in the southern part of Florida.

D. Funds - Annual Expenditures

From the beginning of this work in 1917 until July 1, 1927, all research work on the pink bollworm was carried on from funds allocated to the Federal Horticultural Board for control purposes. Only a very small percent of these funds was spent on research and the breakdown in expenditures, separating research from control during this period is not available. During 1927, 1928, and 1929, appropriations for pink bollworm research were $4800, $5000, and $19,370. From 1930 to 1945, expenditures ranged from $25,286 (in 1934) to $47,603 (in 1932). From 1946 to 1949 expenditures ranged from $41,000 to $64,181. Expenditures during 1950 were $47,350.

E. Examples of Outstanding Accomplishments

Spread of pink bollworm prevented through knowledge gained in research. As a result of information obtained through research, it has been possible thus far to prevent the spread of the pink bollworm to most of the cotton producing areas of the United States and to eradicate it from certain areas in Arizona, Florida, Georgia, Louisiana, Oklahoma and Texas before it became firmly established.

Insecticidal control developed for economical practice in areas of heavy infestations. A combination insecticide containing several chemicals is being successfully used for the simultaneous control of the pink bollworm, boll weevil, cotton aphid, bollworm, and red spider mite.

Cultural practices developed for pink bollworm control. It was shown that early destruction of cotton stalks in the fall followed by thorough field clean-up, early planting of early fruiting, quick maturing varieties of cotton, and proper timing of irrigation had marked effect on pink bollworm infestation, and these have been important advances in eradication and control plans made in the Federal-State pink bollworm control programs.

F. Some Additional Work Needed

Search for more effective insecticide. An insecticide or a combination of insecticides possessing greater toxic action against the pink bollworm than DDT is needed. Only through additional research will this be found. With the many available organic chemicals possessing insecticidal qualities, it is probable that one may be found that is highly effective and which will give economical control of the pink bollworm.

Develop and Improve Cultural Practices. It is important that additional investigations be made of the pink bollworm in relation to cultural and other agronomic practices, the introduction of new varieties of cotton, rotation and soil conservation practices, mechanical cultivation and harvesting and the early fall destruction of cotton stalks. Cultural control is nearly always more economical than insecticidal control. Research thus far has indicated that cultural practices go a long way in controlling the pink bollworm. Research on additional cultural practices might prove to be highly profitable.

Biological Studies. When the pink bollworm spreads to new areas it is important to study it in each new environment to determine its life history and habits, where and how it survives the winters, its host plants, and natural enemies.

COTTON APHID INVESTIGATIONS

(BEPQ - No. I-f-4 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To develop economical methods of controlling the cotton aphid in cotton fields. This aphid is one of several insect pests that materially reduce yield and quality of cotton. The cotton aphid problem is usually aggravated by insecticide applications made for boll weevil and bollworm control. Current work under this project, along with work under related projects, is directed primarily toward the development of a combination of insecticides for the simultaneous control of the cotton aphid along with the boll weevil and other cotton insect pests. Seasonal and geographical surveys are conducted to determine distribution and abundance of the different species of aphids which attack cotton.

B. Currently Active Line Projects

I-f-4-1 - Damage caused by different degrees of aphid infestation to the yield, grade, and staple of cotton. To determine the comparative relationship between varying degrees of aphid infestation and reduction in cotton yield, the effect on grade and staple length of cotton, and the spinning qualities of lint cotton.

I-f-4-2 - Host relationships of cotton aphids. To determine the species of aphids which cause damage to cotton and their various host plants and the possible relationship of these plants to aphid infestations on cotton.

I-f-4-3 - Causes of aphid increase on cotton following the use of insecticides. To determine the exact role that various insecticides have in increasing aphid populations on cotton when these insecticides are applied to control other cotton insects.

I-f-4-4 - Chemical and physical properties of insecticides and their effect on aphid populations. To develop an insecticide for weevil and bollworm control with chemical and physical properties which will not build up aphid populations.

I-f-4-5 - Insecticidal control of aphids, including combinations of insecticides to prevent aphid build-up. To develop an insecticide or a combination of insecticides which will not cause a build-up in aphids when applied to cotton for the control of other insects.

I-f-4-7 - Ecological factors and cultural practices that influence aphid abundance. To determine the extent to which certain ecological factors and cultural practices influence aphid damage.

I-f-4-8 - Varietal differences, and selection and breeding of strains of cotton that are immune, or tolerant to aphid attack. To determine the extent to which varietal differences affect aphid susceptibility and to develop strains of cotton which are resistant to attack by aphids.

I-f-4-10 - Investigations of root aphids injurious to cotton. To develop practical methods of controlling the root aphids which attack cotton; to determine their host plant relationships, particularly with regard to injury following winter cover crops, and to more accurately determine their economic status.

C. History and Evolution of This Work

The cotton aphid has been a pest of cotton in the United States since 1854. Not much research was done on cotton aphid control in early years although aphids have been recorded as pests of cotton for 96 years. Natural enemies, such as ladybird beetles, aphis lions, syrphid flies, and wasp-like parasites usually kept aphid populations in check. Very shortly after calcium arsenate came into wide use for the control of the boll weevil in the 1920's, it was noted that aphids often infested dusted plants in enormous numbers. Sometimes the aphids caused greater injury to the crop than the boll weevils against which the calcium arsenate was applied. They secrete a honeydew that stains the open lint and also reduces tensile strength, and makes cotton difficult to pick. Studies in Louisiana in 1921 showed that nicotine sulphate could be used for aphid control. Every insecticide that showed promise of aphid control has been tested since 1921. Research thus far has shown that new organic insecticides are much more selective in their action against insects than arsenicals and other older inorganic insecticides. Some of these new materials hold great promise in the control of the cotton aphid.

D. Funds - Annual Expenditures

Prior to the 1920's the amount spent on cotton aphid research probably averaged less than $1,000 per year; from 1920 to 1925, less than $2,000. These funds were from appropriations for research on miscellaneous cotton insects. During the 15-year period 1926 to 1940 the average expenditure was probably around $10,000, from 1941 to 1950 the average was $24,500. The 1950 expenditure was $31,900.

E. Examples of Outstanding Accomplishments

Calcium arsenate and DDT determined as causes of aphid build-up. The use of calcium arsenate for boll weevil control and of DDT for bollworm and pink bollworm control killed off natural enemies of aphids and resulted in damaging outbreaks of aphids in treated fields. This discovery made it possible to anticipate these outbreaks and to prevent their occurrence.

Calcium arsenate-nicotine sulphate combination proved to be "knock-out" insecticides. The research which indicated the effectiveness of this combination insecticide for the simultaneous control of boll weevil and cotton aphid, was among the earliest "all-purpose" insecticides.

Cotton aphid control by nicotine sulphate developed. The first insecticide to give practical control of cotton aphids was nicotine sulphate formulated by Department entomologists for this purpose in the 1920's. In the 1930's it was shown in Louisiana that nicotine sulphate could be mixed with calcium arsenate and used as a dual control for the boll weevil and cotton aphid under certain conditions.

The "3-5-40" combination of insecticides developed for cotton insect control. This combination insecticide provides the simultaneous control of the boll weevil, bollworm, cotton aphid, and red spider mites. This is the first insecticide ever developed that gives at least fairly good control of all these insect pests simultaneously.

F. Some Additional Work Needed

Relation of all insecticides used on cotton to the cotton aphid. Every insecticide that shows promise of being used for the control of the boll weevil, bollworm, pink bollworm, or other cotton insects should be studied in relation to the cotton aphid problem. These studies should determine the effectiveness of the insecticide against the aphid, and whether it kills the parasites and predators of aphids, thereby allowing them to build up to injurious numbers.

New insecticides for cotton aphid control needed. The search for effective safe and economical insecticides should be continued through laboratory and field tests. Safe, effective insecticidal materials should be found that will control aphids that attack cotton, along with the other major insect pests, or one that may be effectively and economically added to other insecticides for the simultaneous control of all cotton insect pests.

Studies of resistant strains or varieties of cotton should be continued in cooperation with plant breeders to discover or develop strains or varieties of cotton that will resist or will be partially resistant to aphid attacks.

Additional data on host relationships is needed because the aphids that attack cotton also infest many other host plants. Studies on the host relationships of the different species of aphids that attack cotton may be helpful in developing methods of checking initial infestations in cotton fields and might lead to other practical developments in cotton aphid control.

INVESTIGATIONS ON THE COTTON FLEAHOPPER AND RELATED INSECTS
(BEPQ No. I-f-5 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To discover and develop new methods of controlling the cotton fleahopper and related insects and to improve the known methods of control; to determine the extent to which these insects affect the yield of cotton in various locations throughout the Cotton Belt. This group of insects causes serious injury to the cotton crop in parts of Texas every year and in some years outbreaks are widespread over many States. Investigations are currently directed toward making hibernation and emergence studies during the winter and early spring, making limited surveys to determine the seasonal and geographical abundance of these insects and the amount of injury caused, and conducting experiments with various insecticides.

B. Currently Active Line Projects

I-f-5-1 - Surveys of seasonal abundance of the cotton fleahopper and related insects as an aid in the distribution of insecticides and to assist growers in preventing losses. To be currently informed as to the relative abundance of the cotton fleahopper and related insects in areas where they are often major cotton pests surveys are conducted in order to inform cotton farmers of the need for applying control measures and to provide information that will aid in the distribution of insecticides to areas where needed to protect the cotton crop.

I-f-5-2 - Hibernation, winter survival, and spring emergence of the cotton fleahopper and related insects from wild and cultivated host plants as an index to expected damage and need for insecticides. To be able to forecast with a reasonable degree of accuracy the damage to cotton likely to occur in various locations from attacks of these pests and to provide information as to the probable need for insecticides to control them. To obtain information that will aid to the knowledge of the cotton fleahopper in its relation to climatic conditions.

I-f-5-4 - Tests of insecticides in field plots. To develop practical, low-cost insecticides or combinations of insecticides that will control the cotton fleahopper and related insects on cotton.

I-f-5-5 - Strip cropping and conservation practices in relation to the cotton fleahopper and related insect pests of cotton. To determine the effect of various strip crop and conservation practices on the abundance of fleahoppers and related insects in cotton fields and on the amount of injury these pests cause to cotton.

I-f-5-6 - Differences of cotton varieties in susceptibility to fleahopper damage and in response to insecticides used for fleahopper control. To determine the relation of varieties of cotton to fleahopper abundance and subsequent yields, and to determine the varietal differences of cotton in relation to the effectiveness of insecticides used to control that insect.

C. History and Evolution of this Work

In the early 1920's the Department received complaints from farmers that cotton was not fruiting properly, that young squares forming on the plants were turning yellow and dropping off, and the plants in general were assuming a tall, whiplike growth void of squares and bolls with a subsequent reduction in yield. Most of these early complaints came from southern Texas. Early investigations into the causes of this condition revealed the presence of a small, greenish, insect which is now known as the cotton fleahopper. This insect, with other plant bugs, is primarily responsible for the damage reported. The first actual research conducted by the Department on this group of insects was begun in 1923 at Victoria, Texas. Sulphur was shown to be effective in controlling these insects in 1924 and its use resulted in increasing the yields of cotton. Experiments during the next few years were devoted to developing sulphur as a practical control measure and demonstrating its effectiveness. In the late 1920's and early 1930's research was conducted to determine just how the cotton fleahopper and related insects affect the cotton plant and cause its abnormal growth characteristics. Subsequent investigations at various locations have shown that the cotton fleahopper and other closely related insects damage cotton in every State where this crop is grown. More recent investigations indicate that the population of these insects is greatly influenced by such farming practices as crop rotation, use of winter cover crops, etc., and that they are far more important as cotton insect pests over the Cotton Belt as a whole than was originally supposed. Experiments conducted during the past 5 years have been centered mainly on the newer organic insecticides.

D. Funds - Annual Expenditures

During the period 1924-1933, inclusive, the average annual expenditure was probably about $15,000. From 1934 to 1950 annual expenditures ranged from $12,613 (in 1934) to $18,664 (in 1939) with an average of $16,069. The expenditure in fiscal year 1950 was $16,400.

E. Examples of Outstanding Accomplishments

The discovery of sulphur's effectiveness in controlling the cotton fleahopper and the development of this as a practical and economical method of control did much to make the production of cotton profitable in south Texas and in other areas where these insects often cause serious losses.

The determination that the cotton fleahopper and other closely related insects often cause serious injury to cotton in every cotton producing State, and that supposed failures in boll weevil control were often explained by the presence of these insects, has helped materially in arriving at practical and effective recommendations for cotton insect control in general.

The recent determination that the newer organic insecticides which have come into general use are highly effective against this group of insects in comparatively small dosages has done much to lower the cost of production and increase the per acre yield of cotton in areas where these insects are a problem.

F. Some Additional Work Needed

Determine extent of injury caused by cotton fleahopper and other mirids. There are areas in the Cotton Belt where unexplained losses to the cotton crop still occur annually. In many areas in some years there is a delay in the normal fruiting of the crop and a loss of the "bottom crop" which makes boll weevil and other cotton insect control more difficult and expensive, and results in increased costs per acre to the grower. Such conditions are known to occur in the Piedmont sections of the Carolinas and Georgia, in Tennessee, and in parts of Alabama, Arkansas, and Oklahoma. Additional research is particularly needed in those areas to determine the extent to which insects actually cause this injury and the gains which might result from the use of practical measures to control fleahoppers and related insect pests.

The relation of other crops including legumes grown as soil improving crops to the mirid populations on cotton. Wherever cotton is grown it is attacked by insects belonging to the family Miridae, including such notorious pests as the rapid plant bug, superb plant bug, tarnished plant bug and cotton fleahopper. These insects have many other host plants. Studies of the host plant relationships of these insects to plants other than cotton might furnish information that would be useful in developing farm practices that would prevent or reduce heavy infestations of these insects in cotton fields.

The distribution, host plants, and relation to cotton production of all species of Miridae that occur commonly on cotton in the United States. There are in the cotton fields of this country at least a dozen species of Miridae that are at times abundant. Most of these insects are known to be serious pests of cotton. Little is known about the habits of several species. It is possible that some of them are beneficial predators. There is much to be learned about the distribution, host plants, life history, habits and relation to cotton of all of those insects that occur on cotton in this country.

Insecticides. Additional investigations are needed to determine the insecticides that are effective and economical for use against each of the mirids that are pests of cotton.

PLANT BUG INVESTIGATIONS
(BEPQ No. I-f-6 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To develop methods for the control of plant bugs on cotton. These sucking insects blast squares and injure bolls. Crop injury on individual fields caused by these plant bugs sometimes reaches 50 percent. Research work is centered in the Southwest where all of the American-Egyptian cotton is grown in the United States and where these insects are especially abundant. Current research is directed toward making a long-range study on the effect of an expanded agriculture in the irrigated regions on the abundance and subsequent injury to cotton caused by several species of plant bugs and, through large-scale field tests, to demonstrate the value of using effective insecticidal control measures to increase the yield and improve the quality of cotton.

B. Currently Active Line Projects

I-f-6-1 - Seasonal abundance of plant and stink bugs and need of insecticides for control. To determine the proper time to begin and discontinue insecticide control.

I-f-6-2 - Wild hosts and cultivated crops - their relation to plant bug populations, migration, and damage to cotton. To determine the wild and cultivated host plants of plant bugs and stink bugs and their plant preferences, and the relation of host plants to the insect infestations on cotton.

I-f-6-3 - Insecticide tests in cages to obtain promising materials for field tests. To determine promising insecticides or combinations that justify testing in the field against plant bugs.

I-f-6-4 - Insecticide tests in plots applied by hand dust guns and ground machinery. To develop the most effective insecticide for use under field conditions.

I-f-6-5 - Large-scale insecticide tests applied by airplane. To determine the most effective insecticides and satisfactory methods of applying them for the control of plant bugs by airplane.

I-f-6-6 - Loss in gin turnout and value of seed caused by plant and stink bugs. To determine the actual loss caused by stink bugs and other sucking bugs in gin turnout of lint and loss in value of cottonseed.

I-f-6-7 - Quality of cotton as affected by plant and stink bugs. To determine the actual loss of the quality of cotton caused by stink bugs and other sucking bugs that attack cotton.

I-f-6-8 - Natural enemies of plant bugs attacking cotton. To determine the species of predacious and parasitic insects which attack plant bugs, the degree of control which they exert, the factors which influence their abundance, and their seasonal and geographical distribution.

C. History and Evolution of This Work

Plant bugs have been known to cause serious damage to cotton in the United States since 1855. Two stink bugs, a leaf-footed bug, and the "red bug" or cotton stainer were referred to by the first Entomologist of the Department of Agriculture in his Report for 1855. Several other published records indicate the economic importance of plant bugs to cotton over a period of nearly 100 years. The stink bugs, leaf-footed plant bugs, and cotton stainers vary greatly in their geographical distribution, the so-called "brown cotton bug" being the predominant species of stink bug in Arizona, the "conchuela" in West Texas and New Mexico, and the southern green stink bug in the Southeastern States. The leaf-footed plant bugs occur throughout the Cotton Belt. The earliest investigations on the biology and control of plant bugs by the Department were conducted in Mexico in 1904 and 1905, followed by more intensive work in Texas and Arizona from 1906-1910. Control, then, amounted to hand picking. From 1915-1920 investigations were expanded to include plant bugs causing serious damage to cotton in Georgia and Florida. Hand picking of the insects and the burning-over of woods and fields adjacent to cotton were recommended, then, as the most practical methods of control. During the 1920's investigations on plant bugs were continued in connection with studies on the boll weevil, Thurberia weevil, and pink bollworm in various locations. As cotton production increased in the irrigated regions of the Southwest, and as farming grew more diversified, plant bugs became a greater problem in the economical production of cotton. Studies in 1932 showed plant bugs were generally distributed throughout the cotton-producing areas of Arizona and caused serious reduction in both the quality and quantity of cotton. Large-scale field tests made in Arizona in the late 30's demonstrated the value of insecticidal combinations for plant bug control and the majority of the cotton growers in Arizona were finding their use profitable by 1940. Studies were also made of the disadvantages of the arsenical insecticide combinations from the standpoint of the destruction of colonies of bees and injury to certain crops such as cantaloupes, growing adjacent to cotton, injured as a result of the sulphur. Investigations since 1945 have centered around the development of organic insecticides for plant bug control in the hope that such complications following the use of arsenicals might be avoided. Much progress has been made and emphasis on plant bug control is now with other newer insecticides, the use of which is resulting in the practical and economical control of plant bugs attacking cotton.

D. Funds - Annual Expenditures

Early work done on plant bugs attacking cotton was financed from funds made available through other projects. The total amount spent on plant bug research from 1855 to 1900 probably amounted to less than $5,000. From 1900 to 1920 the average annual expenditure was about $2,000; from 1921 to 1940, $7,500; and from 1941 to 1950, $16,100, ranging from $10,000 in 1942 to $22,100 in 1949. The amount allotted for plant bug investigations during 1950 was $22,000.

E. Examples of Outstanding Accomplishments

Discovered and demonstrated that both quality and quantity of cotton was greatly increased through plant bug control. Demonstrations proved that control of sucking insects in cotton resulted in higher yields of better quality cotton. These demonstrations resulted in almost complete state-wide adoption of the practice of using insecticides on cotton in Arizona.

Insecticidal mixtures for plant bug control developed. This mixture brought about increased yield of better quality cotton and was used extensively by farmers in irrigated sections in the Southwest.

Discovered value of organic insecticides and demonstrated their effectiveness in controlling plant bugs attacking cotton. These insecticides resulted in lowering the cost of cotton production and increased both yield and quality.

F. Some Additional Work Needed

Survey of plant bug damage to cotton needed. Plant bugs often affect the quality more than the quantity of cotton produced. In order for cotton to compete with other natural and synthetic fibers and bring the farmer higher income, it is desirable that losses in the quality as well as the quantity be avoided. Additional research is needed to determine more precisely the extent to which plant bugs affect the quality of cotton in each of the cotton growing States.

Need for measuring effect of agricultural practices on plant bugs.

Additional research is needed to determine the comparative effects of changing agricultural practices -- such as crop rotations, the use of winter crops, and more intensive cultivation of the soil -- on the plant bug populations on cotton.

New insecticides being developed should be thoroughly tested against each of the various plant bugs which attack cotton in an effort to find or develop insecticides that will be more economical and effective than those now being used.

INVESTIGATIONS ON MISCELLANEOUS COTTON INSECTS
(BEPQ No. I-f-7 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To develop control measures for miscellaneous insect pests not included in projects I-f-1 to 6 which cause intermittent damage to the cotton crop. Included in this group are several species of thrips, the cutworms, the cotton leafworm, the webworms, the salt-marsh caterpillar, the red spider mites, grasshoppers, crickets, leafhoppers, flea-beetles, and many other species which are often serious pests of cotton. The cotton leafworm was one of the two most important pests of cotton in the country until the advent of the boll weevil. Whenever outbreaks of any of these pests are reported, whether local or general, efforts are made to investigate the extent of the injury and its cause. Whenever possible during an outbreak of any of these pests, particularly if an effective and economical control is not known, research is conducted on the spot to develop such control. Particular emphasis is currently being placed on developing effective control measures for several species of thrips, probably the most serious pests of cotton in the early stages of its growth. Other pests currently being studied with reference to seasonal and geographical distribution and control are the red spider mites, the cotton leafworm, cutworms and the salt-marsh caterpillar.

B. Currently Active Line Projects

I-f-7-1 - Surveys relating to cotton insects not included in other projects. To have available at all times reliable information in regard to the status of these various cotton insect pests throughout the United States; to furnish helpful information regarding them to cotton growers, agricultural extension workers, and the insecticide industry; to aid in the prompt discovery of any new foreign pests of cotton that may be introduced accidentally from other parts of the world or of native pests that may be adapting themselves to cotton.

I-f-7-2 - Cotton leafworm: Appearance, distribution, abundance and damage in each State. To be able at any time during the cotton-growing season to give reliable information in regard to the presence, distribution, abundance and potential danger from the cotton leafworm; and to cooperate with various State Agencies by furnishing all available information concerning its spread and control.

I-f-7-3 - Thurberia Weevil: Annual Survey to Determine its Status in Arizona. To determine the comparative seasonal and annual abundance of the thurberia weevil in areas where it is now known to occur, to determine any changes in its geographical distribution, and to determine any changes in its status as a cotton pest and the causes of these changes.

I-f-7-4 - Investigations of insects attacking wild cotton in Florida. To determine if these insects have been eradicated from Florida, or if they have spread to other areas.

C. History and Evolution of This Work

The cotton leafworm has been known as a serious pest of cotton since 1793. Because the pest caused an estimated loss of cotton worth $15,000,000 in 1877, Congress appropriated funds to be used by the newly organized Entomological Commission for the investigation of cotton insects in 1878. Entomologists were assigned to all the southern States, even to West Indian Islands, to study this problem. Investigations on the control of this pest have continued until the present time. It had been observed in the early 1800's that the leafworm was sporadic in its outbreaks and was much more destructive in some years than in others. No injury was recorded from the eastern States sometimes, while the crop was practically destroyed in parts of Texas, Louisiana, and Mississippi. It was determined finally that this insect does not overwinter in the United States but migrates in from Central and South America and that it is impossible to predict where or when an outbreak may occur. Paris green was used for the control of this insect as early as 1872. This was the principal insecticide used for the control of the leafworm until 1922, although london purple, arsenate of lead and other arsenical poisons were used to some extent. Calcium arsenate largely replaced paris green and other materials for leafworm control until recently when benzene hexachloride and toxaphene became available.

Thrips too have long been recognized as serious cotton pests, particularly to seedling cotton in the early spring. Their principal damage is in stunting the plants and delaying fruiting. This was not so serious before 1892 when the boll weevil became a pest in this country. Very little research has been accomplished on the control of this insect pest, although it was shown in 1936 that certain cotton varieties were more susceptible to thrips injury than others. Research on the thrip control problem since the development of organic insecticides in 1945 indicates possibility of their control with DDT, benzene hexachloride, and others.

Red spider mites have been known to cause serious injury to cotton since 1893. They are usually sporadic in their attacks, rarely occurring in damaging numbers in the same location for two successive years. Kerosene emulsion was used early for the control of these mites. This was replaced by sulphur, the standard recommendation for control of red spider mites on cotton since 1905. Experiments with new compounds are being conducted now and several show promise.

There are many other insects besides those mentioned which often cause serious injury to cotton. Research on a number of these dates back to the late 1800's. In most cases research on these various cotton insects has kept pace to a fairly reasonable degree with the demands, and it is rare that a problem arises concerning a particular pest for which research cannot provide at least a partial answer. Investigations are made of these when opportunity affords. The problem has recently become more complex, however, owing to the use by cotton growers of new chemicals which are powerful insect killers and which show no preference for the injurious insects over the beneficial ones. Some of the pests previously considered of minor importance to cotton are now assuming more important roles because of the destruction of their natural enemies.

D. Funds - Annual Expenditures

Funds have been provided for research on insects attacking cotton since 1878, the first direct appropriation being the amount of $5,000 during that year. The amounts spent during the early years for research on the insects now included in this project are difficult to determine but would probably average about $3,000 annually until 1910. From 1910 to 1926, inclusive, the average annual expenditures for these insects approximated $6,000 and from 1927 to 1934, inclusive, they averaged about $30,000. Since 1934 the annual expenditures have varied from approximately $17,000 in 1941 to approximately $5,500 in 1944, and averaged about $8,000. The amount spent during 1950 was approximately $11,000.

E. Examples of Outstanding Accomplishments

The determination that the cotton leafworm does not overwinter in the United States but migrates from Central and South America provided important information on the habits of this pest. Farmers formerly wasted effort in cleaning up fields in which the leafworm was believed to hibernate.

Effective insecticides discovered for cotton leafworm control. The effectiveness of paris green, calcium arsenate, benzene hexachloride and toxaphene in controlling the cotton leafworm was discovered and have provided the cotton growers practical and effective means of controlling this pest.

Use of sulphur to control red spider mites on cotton. The discovery of the value of sulphur for red spider mite control and its continuous use for this purpose since 1905 has provided cotton growers an effective and economical means of controlling outbreaks of this pest.

Readily available information on the life history, habits, and control of the various insect pests of cotton, which occur in intermittent outbreaks, has provided basic information for development of control methods.

Study made on dispersal of insects in the upper air. Comprehensive research on the dispersal of insects in the upper air was conducted in connection with several aspects of this project. The published report on this outstanding research is a standard reference to studies on insect dispersal in the upper air the world over and has provided much useful information on the subject.

F. Some Additional Work Needed

Additional research on timing and methods of application of insecticides needed. Many of the so-called minor pests of cotton have become major pests when environmental conditions changed. Recently, the widespread use of the organic insecticides for the control of major pests has created new problems in connection with the pests covered by this project by destroying their natural enemies. There is evidence that the proper timing of insecticide applications and the use of minimum dosages of insecticides might solve some of these problems, and additional research is needed to provide the answers.

Growth of insect resistance to insecticides. It seems likely that resistance to insecticides may develop especially among the spider mites and research to determine how to meet such an occurrence is needed.

The cotton leafworm: food habits, distribution and spread. There is little information available as to where the cotton leafworms originate, or why they vary so greatly in numbers from year to year. The first moths of the cotton leafworm reach the United States each year during April, May or June. In cooperation with all or many of the cotton growing countries between the United States and the Argentine Republic much research will be needed in order to obtain adequate information to explain the distribution, appearance and abundance of this insect. Although, in the United States cotton is the only known host plant, this species may develop on other malvaceous plants in Central and South America. A comprehensive study of the distribution of this insect and its habits in other countries might prove of great value and enable reliable forecasts to be made as to when this insect is likely to be serious in the United States.

Information needed concerning the life history, host plants, distribution and causes of local outbreaks of many of the minor pests of cotton. The corn silk beetle, Luperodes brunneus (Crotch), is occasionally a serious pest of cotton over wide areas. Nothing is known as to the food habits of the larvae of these beetles. This information might be of much value in preventing outbreaks of these beetles. There are several other beetles and many other insects that are at times minor pests of cotton about which little information is available.

BASIC RESEARCH ON COTTON INSECTS
RELATING TO FUNDAMENTAL FACTORS AFFECTING CONTROL
(BEPQ and BPISAE - RM:b-43 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to conduct basic or fundamental research which will (1) determine degree of toxicity and correct formulation of new chemicals to be used in field tests against cotton insects, and to eliminate from field testing those chemicals which do not have sufficient toxic action to justify it; (2) determine the degree of toxicity of promising new insecticides on beneficial insect species on cotton; (3) determine the relationship existing between use of various insecticides to the total insect population in cotton fields; (4) determine the manner in which cotton insects are killed through the use of various poisons; and (5) determine the basic factors underlying plant relations to insect attacks and to insecticide applications. As new chemicals are developed and become available these are first tested against various cotton insects under laboratory conditions to establish degree of toxicity. Many chemicals never go beyond this stage. For chemicals demonstrating toxic action, further laboratory experiments are conducted to determine proper dosages and formulations required to give a high degree of mortality. After this has been determined, comparative tests are conducted in field cages using insecticides of proven value as standards of comparison. If a new compound compares favorably with those of known value in field cage tests, it is then recommended for testing under field conditions. At this stage, it is also tested in the laboratory or in field cages against beneficial insects to determine degree of toxicity against these insects. Through tests with insects collected under field conditions, the comparative relationship of the use of these insecticides to the total insect population of cotton fields is determined. In laboratory tests, also, the degree of total toxic action due to contact effect, fumigating effect, stomach effect, or effect due to plant absorption of the fumes or condensation of the fumes on plant surfaces is determined. Cage tests in which punctured cotton squares are collected from fields treated with these insecticides are conducted to determine the effect of each of these on boll weevils developing inside of punctured squares. Field tests are conducted to determine the relationship of the field use of these insecticides to the physiology of the cotton plant. Laboratory and greenhouse tests are made to establish the fact of systemic action of various new chemical compounds, that is, action caused by the plant taking up through its roots or absorbing into its tissues these chemicals and translocating them to other parts of the plant while retaining their toxic qualities. If such action is demonstrated, further tests are conducted to determine correct dosage and formulation and correct methods of applying these materials, whether in water solution to the soil, as sprays or dusts to the plants, as seed treatments, etc. Studies are made of the various organs and tissues of insects treated with these various insecticides to determine which are affected and the degree. Biochemical studies are made to determine exact chemical composition of various insects and the various organs of the insect's body.

B. Currently Active Line Projects

RM:b-43-1 (BEPQ) - Toxicity to the boll weevil of new chemicals and formulations. To discover the relation to the boll weevil of new chemicals and new formulations not previously tested against this insect. To test any material in various mixtures in the laboratory known to be toxic to the boll weevil in the hope of obtaining information that may prove useful in developing formulations of practical value for boll weevil control.

RM:b-43-2 (BEPQ) - The relation of insecticides to the insect populations of cotton fields. To determine what insects occur in cotton fields under various conditions and in different areas and the relative abundance of each species as a basis for other studies. To study the relation of each widely used insecticide to the whole insect population of cotton fields. To determine what effect the continued use of each insecticide has upon each species of insect that occurs abundantly in cotton fields.

RM:b-43-3 (BEPQ) - Toxicity to the cotton aphid of new chemicals and formulations. To (1) determine in laboratory tests the effect of new chemicals and formulations not previously tested on the cotton aphid and (2) to determine the relation between cotton aphid control and the control of other cotton insects by such chemicals and formulations.

RM:b-43-4 (BEPQ) - How insecticides kill cotton pests. To determine exactly how effective insecticides kill cotton insects in the hope of developing methods of increasing their effectiveness. In initial work, special attention is given to the determination of how calcium arsenate, benzene hexachloride and chlordane kill the boll weevil, how nicotine and benzene hexachloride kill the cotton aphid, and how DDT kills the bollworm and pink bollworm. Determine if the toxicity or effectiveness of the chemicals may be increased by using formulations or methods of application that have not previously been used.

RM:b-43-5 (BPISAE) - Physiological factors involved in cotton plant relations to insect attack and to insecticide applications. Determine basic factors underlying cotton plant relations to insect attack and to insecticide application, determine to what extent these factors may be inherited or influenced by cultural practice, and how such information can be utilized to increase yields and fiber quality.

RM:b-6 (BEPQ) - Toxicity to red spiders of new chemicals and new formulations. To determine the effects of new chemicals and new formulations on red spider mites. To correlate data concerning effect of the insecticides on red spider mites with similar data on the boll weevil and other cotton pests with the purpose of obtaining information that may prove useful in the formulation of an insecticide which will be toxic to all important cotton pests.

RM:b-43-7 (BEPQ) - Toxicity to the cotton leafworm of new chemicals and new formulations. To determine the effects of new chemicals and new formulations on the cotton leafworm. To correlate data concerning effect of the insecticides on the cotton leafworm with similar data on other cotton insects for the purpose of obtaining information which might be useful in the formulation of an insecticide that will be toxic to all important cotton pests.

RM:b-43-8 (BEPQ) - Toxicity to the cotton fleahopper and related insects of new chemicals and new formulations. To determine the effects of new chemicals and new formulations on the cotton fleahopper and related insects. To correlate data concerning effect of the insecticides on the cotton fleahopper and related insects with similar data on other cotton insects with the purpose of aiding in the development of an insecticide or a combination of insecticides which may be toxic to all major cotton pests.

RM:b-43-9 (BEPQ) - Toxicity to stink bugs of new chemicals and new formulations. To determine the effects of new chemicals and new formulations on the several species of stink bugs which attack cotton. To correlate data concerning effect of the insecticides on the stink bugs with similar data of other cotton insects for the purpose of aiding in the formulation of an insecticide which may be toxic to all the important cotton pests.

RM:b-43-10 (BEPQ) - Toxicity to the bollworm of new chemicals and new formulations. To determine the effect of new chemicals and new formulations on the bollworm. To correlate data concerning effect of the insecticides on the bollworm with similar data on other cotton insects with the purpose of obtaining information that may aid in formulating an insecticide, or a combination of insecticides which will be toxic to all of the important cotton pests.

RM:b-43-11 (BEPQ) - Toxicity to beneficial parasitic and predacious insects of various chemicals and formulations used in cotton insect control. To determine the effects of various insecticides on each of the important predacious and parasitic insects that are of economic importance to cotton. To correlate data concerning effect of the insecticides on beneficial insects with similar data on various species of injurious insects on cotton for the purpose of obtaining information which may be of value in the formulation of an insecticide that will be effective against the injurious species but will not be highly toxic to the beneficial species.

RM:b-43-12 (BEPQ) - Effect of varied climatic conditions on the toxicity of new chemicals and new formulations to the boll weevil, cotton aphid, red spiders, thrips, cotton fleahopper and related species of insects, bollworm, pentatomids, and other insects injurious to cotton. To determine the effect of varied climatic conditions n the toxicity of new chemicals and new formulations to several species of cotton insects and red spider mites. To provide data on which to base control recommendations which will recognize the fluctuation of climate from day to day. To provide a comprehensive study of climatic conditions as they relate to the toxicity of new insecticides in order to answer some of the problems relating to inefficiency of some insecticides encountered under some conditions.

RM:b-43-13 (BEPQ) - Aphid resistant characters in cotton. To discover what part the total number of hairs on cotton leaves play in aphid resistance. To learn what part, if any, the location of hairs on cotton leaves play in aphid resistance. To study apparent inter-

LIBRARY
UNIVERSITY OF ILLINOIS

relationship between hairiness, acidity of cell sap, and aphid resistance. To assist plant breeders in discovering ways in which the characters found detrimental to aphids might be introduced into productive and otherwise desirable varieties.

C. History and Evolution of this Work

It has been realized for many years that basic research lagged far behind applied research in the field of cotton insect control, and, in fact, in insect control in general. This was due largely to public demand for immediate information on the effectiveness of new insecticides and other practical methods of control. The research staff at the various field laboratories had neither the facilities nor the personnel to conduct basic research on a high level, even though many of them made valuable contributions to basic research over a period of many years. The development of chemical methods of controlling insects has been largely a "hit and miss" endeavor. When a new chemical compound was developed or discovered, it was routinely tested to determine its toxic value against insects. It was largely by accident that the chemical possessed toxicity.

With the rapid advances being made in the field of organic chemistry whereby literally hundreds of thousands of compounds may now be made available, it is felt that by conducting histological and physiological studies of insects to determine which organs or tissues are most susceptible to degeneration or deterioration by various toxicants, combined with biochemical investigations to determine the exact chemical content and chemical structure of these, compounds may be discovered by design which will attack any given organ or tissue in an insect's body and result in its death. Likewise, when the chemistry of the various insects is known, it is felt that compounds may be made which will be extremely toxic to insects but non-toxic to man and other warm blooded animals. That plants will take up and translocate certain toxic chemical compounds is now well-known. Out of the toxic chemicals safe to use, none have been prepared until recently in such form that plants can absorb and translocate them. It may be possible through a study of the chemical structure of compounds known to be taken up by plants, as for example nitrogen, potassium, phosphorus, etc., in their various forms, that a linkage can be found whereby a toxic radical may be hooked on or linked to some chemical form of these and carried into the plant system in this manner. None of the so-called systemic insecticides known remain highly toxic to insects on plants for longer than a few days. They usually lose their toxic value rapidly after even a few hours exposure. It is believed possible that through chemical investigations compounds may be discovered which will remain effective over long period after application, which may become more toxic instead of less toxic to insects with prolonged exposure, and which will neither be toxic to plants nor to warm-blooded animals.

Researches of the above nature were made possible through the Research and Marketing Act of 1946 and preliminary investigations on fundamental factors relating to the control of cotton insects were started in 1947 and have continued to date. Progress has been slow, as with any type of basic research, but definite progress has been made.

D. Funds - Annual Expenditures

This project was started on September 30, 1947. Appropriations for fiscal years 1948, 1949 and 1950 were $50,000, $59,100, and $59,500, respectively, for BEPQ, and $4,575 in 1948, $5,000 in 1949, and $10,000 for 1950 for BPISAE. Total expenditures were $54,575 for 1948, $64,100 for 1949, and $69,500 for 1950.

E. Examples of Outstanding Accomplishments

Some insecticides were shown to kill immature boll weevils developing inside punctured cotton squares, in addition to killing the adult insects as a result of their normal field usage. (This was demonstrated originally in field tests under BEPQ - No. I-f-1.) Four new insecticides now are under investigation that are highly effective in this manner.

Octamethyl pyrophosphoramide and several other chemical compounds are taken up by the cotton plant through applications to the soil, to the plant itself in dusts or sprays, or to the seed prior to planting and translocated to other parts of the plant in sufficient quantities to kill aphids, spider mites, and other insects when these feed on treated plants. Plants thus treated remain toxic to insects over a comparatively long time.

Several insecticides have been shown to kill various cotton insects through contact action, stomach action, direct fumigating action, and through action resulting from plant absorption of the vapors or condensation of the vapors on plant tissues.

Histological studies on bollworm larvae treated with dieldrin show marked degeneration or other abnormality in tissues of the alimentary canal, midgut, fat bodies and malphigian tubules. Every fat body examined in treated specimens was found to be affected, indicating an affinity of the toxicant for fat. Similar studies using DDT and calcium arsenate failed to show histological change to the extent of those caused by dieldrin.

F. Some Additional Work Needed

Tests of new chemicals. Laboratory and field cage toxicity tests should be continued with new chemicals as these are synthesized or discovered against each of the injurious insect pests of cotton. Any of these found to be effective should be further tested to determine the proper dosages and formulations to be used in large-scale field experiments.

How insecticides kill cotton insects. Physiological, histological, and biochemical studies should be made on each species of the injurious insects attacking cotton in an effort to determine the mode of action of various insecticides against these in an effort to determine which organs or tissues are most vulnerable to attack by chemical action and to serve as a basis for developing new chemicals especially designed to attack the weak places in the physiology of the insect.

Possible use of systemic poisons against cotton insects. Emphasis should be placed on research with systemic poisons - those which are taken up by plants and translocated, thereby rendering the plant toxic to attack by various insects. This phase of economic entomology is comparatively new and its possibilities have not been explored in the light of the new chemicals which have been developed and are being developed.

Basic research a continuous need. This work project is new and covers many phases or lines of basic research on cotton insects and only a start has been made on any of them. Progress may be slow on many lines, and attention must be given to all of the insects mentioned and many others that are pests of cotton. The various climatic, soil, and other environmental factors involved must be given full consideration. Because new problems are introduced by changes due to improvements and discoveries, certain phases of this research probably will be needed as long as cotton continues to be an important commercial crop in the United States.

COTTON INSECT SURVEY

(BEPQ - Federal-State - Incipient and Emergency Outbreak Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to (1) determine by means of field observations during the growing season the status of the major insect pests of cotton in order to furnish factual information on when and where insecticide applications should be made to control these pests; (2) advise growers so they can effectively apply insecticides if needed; and (3) guide the distribution of insecticides and assure that they will be locally available to growers. Insect pests cause very serious losses to cotton, and the average reduction in yield over the entire cotton-growing area has been as high as 20 percent in some years. Research has shown that by the timely and proper use of effective insecticides much of these losses can be prevented and the grower can make appreciable savings. Under conditions of high insect populations the use of effective insecticides applied at the right time may mean the difference between a profitable crop and practically no return. There is need to keep the farmer continuously informed regarding the materials to be used and to guide industry in supplying these materials. To produce cotton and avoid waste of seed, fertilizer, and labor it is essential to combat insects. Farmers need information on how and when to use materials to prevent losses and need to be encouraged to utilize information gained through research. Currently, on the basis of field data obtained cooperatively with State agencies concerning the status of cotton insect pests, advice is given to farmers at weekly or more frequent intervals by State Extension workers over the radio, in newspapers, and through correspondence to guide them in carrying out effective control of cotton insects. Information is supplied to cooperating State workers and others interested on a National basis to aid in planning programs and encouraging farmers to protect their cotton crops. Information is also supplied to industry to aid in distributing insecticides so that they will be available locally to meet demands for use.

B. Currently Active Line Projects

Does not apply.

C. History and Evolution of This Work

During World War II calcium arsenate--the insecticide then most widely used for cotton insect control--was in short supply. There were heavy and insistent demands for materials to control these pests throughout the Cotton Belt. To aid the agencies responsible in channelizing available supplies to areas where the need was the greatest, field surveys were carried out in an effort to anticipate the development of cotton insect infestations. This resulted in facilitating the distribution of insecticides in an equitable manner on the basis of greatest need. Accompanying this there was developed a plan of advising farmers on the need for and timing of applications to assure most effective utilization of limited supplies. Following the war, with the development of new effective insecticides for use against cotton pests, it was essential to keep the farmers advised on how to use these materials and to obtain current information as to the need for various kinds of materials in local areas. The advisory aspects of the work were therefore increased and developed during the years immediately following the termination of hostilities. The development of heavy infestations of cotton insects and the increased interest on the part of the cotton farmer to protect crops have increased the difficulty of appraising the quantities of insecticides that will be needed. Newer insecticides cannot be produced and made available to the farmer on short order. It is necessary that production programs be adequately planned in advance. When insect infestations exceed anticipated intensity or more growers use insecticides, supplies of the preferred materials may be short, and there is need to advise industry on where to distribute them and to encourage the use of other effective materials when necessary. The cotton insect survey has, therefore, developed into a broad, currently advisory service, conducted cooperatively and is utilized by the farmer, those associated with cotton production, and the industry that serves the farmers by supplying insecticidal chemicals.

D. Funds--Annual Expenditures

Annual expenditures have ranged from $36,000 in fiscal year 1944 to $72,000 in fiscal year 1950, and averaged $58,000.

E. Examples of Outstanding Accomplishments

Cotton insect survey aids in distribution of insecticides and reduction of crop losses. The cotton insect survey made it possible for cotton farmers to get insecticides when and where needed to control the insects that threatened their crops during World War II and thus prevented material losses. Industry has been able, with the aid of the survey, to gear its production of insecticides to meet the increased demands and to distribute materials to places where the need is greatest. Outstanding evidence of the benefits of the work have been increased yields and the fact that no serious crop losses resulted from the inability of farmers to get effective insecticides when and where they wanted them. In periods of high insect population and unexpectedly large insecticide requirements such as occurred in the 1950 season this is an accomplishment of no small significance.

Cotton insect control expanded as a result of the survey. Sound cotton insect control has been greatly expanded as a result of the survey activities. The number of farmers applying control measures has increased more than 100 percent in the last few years, much of which is a result of the advisory program made possible because of the survey. The acreage where cotton insect control is applied has increased approximately 15 percent since the program was initiated. The average annual increase in use of insecticides for cotton insect control has been approximately 30 percent during the last five years.

F. Some Additional Work Needed

The benefits from surveys which have provided the basis for timely advice are recognized by the cotton farmer, Extension Service, the cotton industry, and the industry that produces insecticides. It is the type of work that cannot be supplied except through leadership and cooperative undertaking and the service should be continued.

PROBLEMS OF ORGANIZATION AND OPERATION OF FARMS (COTTON)
(BAE - A-1-20 - Federal-State - Regular Funds)

(Related work in this project is discussed in other commodity chapters and in chapter 24 "Economics of Production".)

A. Purpose and Nature of Current Work

To (1) learn the variations in practices used in producing cotton across the Cotton Belt with respect to degree of mechanization, use of fertilizer and other materials, and techniques, on farms of different sizes within an area and between areas, and (2) compare the efficiency of production among farms and areas. This project conducted in 35 type-of-farming areas in cooperation with 10 Southern Agricultural Experiment Stations.

B. Currently Active Line Projects

A-1-20-45 - Practices used in the production of cotton.

C. History and Evolution of this Work

(See Chapter 24, "Economics of Production")

D. Funds--Annual Expenditures

(See Chapter 24, "Economics of Production")

E. Examples of Outstanding Accomplishments

Provision of recent base or bench mark for cotton production practices and for organizational details of farms producing cotton. The production practices information may serve as a basis for increasing the effectiveness of educational activities. Details are available - by size of farm for major types of farming areas - on insect control, fertilizer, and seed treatment practices, and data are provided on the kinds and quality of planting seed used. These data indicate for many areas a pronounced lag between farm practice and modern recommendations and potentialities for control of insect damage, and seed born fungi, and improvement of product through better quality seed.

Organizational data (including details for size and tenure of farms, crops grown, livestock owned, labor supply, machinery and equipment used, and sources of farm power) may be used: (1) to evaluate the feasibility, for types of farms and regions, of different cotton production methods which arise as a result of technological developments. As an example, information suggests that generally small cotton farms east of the Mississippi River will not find partial mechanization, i.e. mechanization of all operations except hoeing and harvesting, of cotton production to be economically advantageous. Information also indicates that given the present state of technical development and the cost of mechanical cotton pickers, the economic use of these machines will be restricted, in the main, to large farms, of generally level topography, and cotton yields approximating a bale per acre. (2) to realistically appraise the economic effect of agricultural policy proposals concerning cotton production. For example, a basis is provided for estimating practicable short run alternatives to cotton production by size of farm should cotton acreage reductions be required by agricultural policy, and data are available for estimating in what production areas and on what sizes and types of farms cotton acreage would increase if controls were lifted.

Provision of basic cotton production cost data. These data may be used to indicate the relative efficiency with which resources are used in cotton production between types of farming areas, and between different sized farms within areas.

F. Some Additional Work Needed

(See Chapter 24, "Economics of Production")

FARM COSTS AND RETURNS (COTTON)
(BAE - A-1-23 - Federal-State - Regular Funds)

(Related work in this project is discussed in other commodity chapters and in Chapter 24, "Economics of Production")

A. Purpose and Nature of Current Work

To measure changes from year to year over a period of years and to keep current estimates of acreage and livestock numbers, investment, costs and returns on important sizes and types of commercial farms in selected major type-of-farming areas. Such estimates provide farmers and others with information on annual changes in costs and returns in farming from 1930 to the present.

B. Currently Active Line Projects

A-1-23-10 - Farm costs and returns on small scale and commercial family-operated cotton farms, Lower Piedmont.

C. History and Evolution of This Work

(See Chapter 24, "Economics of Production")

D. Funds--Annual Expenditures

(See Chapter 24, "Economics of Production")

E. Examples of Outstanding Accomplishments

Work on the above line projects is not yet completed. (See Chapter 24, "Economics of Production" for general statement on accomplishments)

F. Some Additional Research Needed

(See Chapter 24, "Economics of Production")

ECONOMICS OF FARM MECHANIZATION AND OTHER IMPROVED TECHNIQUES (COTTON)
(BAE - RM-b-62.5 to 9 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

To (1) learn the rates of performance and the operating costs, including the effect on yield and quality of cotton, for the newer type machines, such as the mechanical cotton picker, the mechanical stripper, and the flame cultivator and (2) learnthe effect of mechanization and associated technological developments on the costs of producing cotton and on the organization, operation, and income on farms of various sizes that have different physical resources. Work during the early phases of the project primarily obtained and analyzed information on costs and performance of the machines under various operating conditions, collecting this from farmers and experiment stations. Emphasis is now being given to an economic evaluation of mechanization and associated technological developments and their effects on costs of producing cotton and on farm incomes, first on individual farms, then for certain cotton-producing areas. This work is being done in cooperation with the experiment stations of the States indicated in Section B.

B. Currently Active Line Projects

RM:b-62.5 - Economics of cotton mechanization in Mississippi. To ascertain the economic feasibility of using the newer technological developments in cotton production in the Delta area, including their effect on costs and on farm incomes. Emphasis is given to the mechanical cotton picker and mechanical and chemical weed control.

RM:b-62.6 - Economics of cotton mechanization in Texas. To learn the possibilities and the economic feasibility of complete mechanization of cotton in the cotton-producing parts of the Plains areas. Study of the mechanical stripper is emphasized.

RM:b-62.7 - Economics of cotton mechanization in North Carolina. To learn the possibilities and economic feasibility of the use of newer technological developments with particular reference to the mechanical cotton stripper in the Piedmont area.

RM:b-62.8 - Economics of cotton mechanization in South Carolina. To learn the possibilities and economic feasibility of increased mechanization in cotton production, particularly the use of the mechanical cotton picker in the Coastal Plains area.

RM:b-62.9 - Economics of cotton mechanization in California. To learn the economic feasibility of complete mechanization of cotton production in California with special reference to the effect of the mechanical cotton picker on the costs of producing cotton, as well as on the competitive position of mechanized cotton production relative to alternative enterprises.

C. History and Evolution of This Work

Considerable research on the cost of operating tractors and other machines has been conducted by BAE and Southern Agricultural Experiment Stations in connection with other lines of work. But farmers have only recently had the mechanical cotton picker, the stripper, and the flame cultivator.

A reconnaissance study of the mechanical cotton stripper was made in Texas in 1944 and a study of the mechanical picker was made in California in 1945. They were conducted cooperatively by BAE and the agricultural experiment stations. Comprehensive studies of the economics of cotton mechanization were begun late in 1947 when RMA funds became available.

D. Funds--Annual Expenditures

During 1944 and 1945 a total of about $8,000 was used for economic studies of the mechanical stripper and picker. RMA expenditures by the Department on the above line projects in fiscal years 1948, 1949, and 1950 have been approximately $17,000, $33,000, and $44,000 respectively.

E. Examples of Outstanding Accomplishments

Results of these studies have provided useful guides as to costs and performance that might be expected. Most farmers cannot afford the costly trial-and-error way of learning whether an expensive machine or practice will pay on their farms. Studies in the Mississippi Delta show that it takes 155 man-hours to produce a bale of cotton with one-row mule-drawn equipment, and hand chopping and picking. Using tractor-drawn equipment and a mechanical picker reduces the man-hours to 45, and by also using the rotary hoe and flame cultivator the time was reduced to 30 hours. The study indicates that if cotton production were completely mechanized and all hand work eliminated, a bale of cotton could be produced in the Delta with only 10 man-hours of work. If chemical weed control, now in the experimental stage, becomes practicable on farms, complete mechanization will be possible.

In general, a mechanical cotton picker must harvest 100 bales or more in a season if it is to be as economical as hand picking at $2.50 to $2.75 per hundredweight of seed cotton. About half of the total cost, or about $40 per bale (assuming a volume of 100 to 125 bales harvested per season), is for machine operation (including labor, power, repairs, depreciation and interest) and the other half represents loss in grade and waste in the field.

In 1947, mechanical strippers in the High Plains of Texas harvested an average of 64 bales per machine. Average cost of machine operation was $6.30 per bale on dryland cotton not previously harvested by hand and $21 per bale where cotton was machine stripped after hand snapping. There was very little difference in the value of cotton harvested after frost by hand snapping and by machine. But the average value of cotton harvested between September 15 and November (before frost) was $20 to $25 per bale higher than for cotton harvested between November 16 and January 15 (after frost). In the absence of an artificial defoliant cotton cannot be satisfactorily stripped by machine before frost.

The flame cultivator helps in weed control but is not the complete solution. The cost of operating a four-row unit, including labor, power, fuel for flamer, repairs, depreciation and interest was about $1 per acre, per time over, in 1948.

F. Some Additional Work Needed

Economic research to keep abreast of the notable technical developments. Important changes are being made in ginning techniques, and in mechanical cotton harvesters, and chemical weed control is emerging as a potential substitute or supplement for present weed control methods. Additional economic research should be provided to determine the effects of these emergent technological developments upon production costs and upon farm organization in order that farmers may be informed as a guide to decisions.

Research as to results in differing areas and under varying conditions. The physical resources, size of farm, and other conditions vary widely throughout the cotton producing areas of the United States. The new techniques of production will thus have different potentialities for affecting costs and returns on cotton farms according to the conditions which apply. An evaluation of their economic effects over a wider range of conditions is needed so that at least a large proportion of the cotton farmers may benefit by the facts and relationships disclosed.

Research to evaluate the effect of technological developments on the entire Cotton Belt. When results of the various situations are available an over-all evaluation of the effects of mechanization and associated developments on the agriculture of the South in general and of cotton in particular will be needed.

See also Chapter 24, BAE, RM:b-62.

EQUIPMENT AND METHODS FOR MECHANIZING COTTON PRODUCTION
(BPISAE - RM:b-56 - Federal-State-RMA Funds)

A. Purpose and Nature of Current Work

To (1) develop efficient equipment and methods for mechanizing cotton production, especially on small farms, including defoliation equipment, (2) completely engineer the production of cotton in all of its phases, especially with reference to the small farmer, and (3) develop improved methods for defoliating cotton.

B. Currently Active Line Projects

RM:b-56-1 - Factors affecting cotton leaf response to chemical defoliants. To determine the extent to which either varietal or environmentally induced variations in leaf structure, chemistry, and metabolism influence degree and efficiency of reaction between the leaf and chemical defoliants.

RM:b-56-2 - Develop or improve machinery for crop residue disposal and seedbed preparation. To develop or improve methods and equipment for the efficient and economical disposal of cotton stalks and cover crops. To develop or improve methods and equipment for seedbed preparation, with particular reference to stands, grass and weed control, and ensuing operations.

RM:b-56-3 - Develop or improve machinery for planting and fertilizing. To develop and improve methods and equipment for the treatment of cottonseed; for the precision planting of cottonseed at high speeds and for the planting of cottonseed at specified rates and intervals; and for placement of both liquid and granular fertilizers simultaneously with planting or cultivating.

RM:b-56-4 - To develop and improve machinery for cotton insect and plant disease control. To develop or improve methods and equipment for the economical and efficient application of insecticides and fungicides, both liquid and dust, on both large and small farms, with special emphasis on the durability of the equipment and its multiple use on the farms.

RM:b-56-5 - Develop or improve machines and methods for the control of grass and weeds in cotton. To develop or improve both methods and equipment for grass and weed control in cotton mechanically, by flame, chemicals, or otherwise.

RM:b-56-6 - Develop or improve equipment for harvesting cotton (including defoliation). To develop or improve methods and equipment for economical harvesting of cotton by machinery on both large and small farms; and to develop generally reliable methods and equipment for defoliating the cotton as an aid to machine harvesting.

RM:b-56-7 - Development and evaluation of more effective cotton defoliants. To make a basic study of chemical-plant reaction among all known defoliants, either practical or otherwise, so as to provide a sound approach to the development of more efficient chemical defoliants for cotton.

RM:b-56-8 - Develop methods for controlling second growth in cotton.

To develop methods of controlling second growth (suckering or sprout-in mature plants) in cotton which constitutes a serious hazard to mechanized harvesting since such leaves are not removed by current defoliants. Control may be found possible through better defoliants, through use of growth regulating chemicals, through cultural practices, or by varietal selection.

C. History and Evolution of This Work

Although defoliation research was initiated in 1938 the intensive investigations started only when both spindle pickers and strippers spotlighted the need for leaf removal in 1942. Regional Cooperative research was begun with establishment of this project in 1947.

In the fall of 1946 cotton production and harvesting (including defoliation) machinery investigations were initiated in a preliminary way at Stoneville, Mississippi.

The following year coordinated cotton mechanization research programs were initiated in five additional States (Alabama, California, Oklahoma, South Carolina, and Texas), with each State being assigned to one or more phases of the program - for instance one State is responsible for the crop residue and seedbed preparation phase, whereas several other States are responsible for the harvesting phase because of the varying conditions and the need of different types of machines, such as strippers and spindle type pickers; weed control also because of varying conditions, due to different types of weeds and climate; and so on.

D. Funds--Annual Expenditures

In the fall of 1946 (fiscal year 1947) preliminary work was initiated with $7,500 from regular funds. Since then R.M.A. funds have been available as follows: $70,000 in 1948 and 1949, and $100,000 in 1950.

E. Examples of Outstanding Accomplishments

A spiral brush stripper has been developed and tested for use in particular cotton areas which has created interest among farmers and machinery manufacturers. Improvements credited to this stripper include: (1) higher field recovery of seed cotton, (2) less gathering of stalks and limbs, (3) increased flexibility that reduces the exactness with which the stripper must be driven, and (4) simplicity of design which should reduce the cost of construction.

Special steel knives have been developed as an aid to stalk disposal which are used in combination with the conventional rolling stalk cutter. The knives are mounted rigidly on regular cultivator feet and are set to run underneath the ground surface at an angle with the direction of travel. The knives shear the stalks immediately above the root area.

Equipment was developed for applying anhydrous ammonia simultaneously with the bedding operation, by installing special tool bars and regular anhydrous ammonia applicators on the tractor ahead of the middle breakers. One pre-planting operation is saved by this installation.

A flat-shaped burner, featuring a short, broad flame and foolproof adjustments, was developed for use in flame cultivation. The flame tends to flow rather than bounce when striking the ground at the base of the cotton plant, which permits flaming to begin at an earlier date. Slightly higher operating speeds may also be obtained with the increased exposure, and the burner requires virtually no attention after its initial setting.

A tractor has been equipped for multiple use for weed and insect control in cotton by mounting a shovel cultivator toward the front, a flame weeder on the rear, and a spray system on the extreme front. One tractor may then serve for all weed and insect control procedures throughout the season without the changing of the equipment.

Special fenders were developed for a commercial cotton stripper which considerably reduces field losses. These fenders reduced stripping losses otherwise resulting from tractor wheel damage, by about 76 percent. Several hundred sets have already been built by farmers in the North Texas areas after this pattern.

A planter-cultivator combination has been worked out on the project which permits the replanting of "skips" in the stand without changing equipment even up to the final cultivation .

Regional Coordination. Through establishment of an annual defoliation conference (April 1947) and the combined activities of a Steering Committee and an Information Clearing House it has been possible to include state, federal, and commercial research personnel in the planning execution, evaluation, and publication of all progress made in this field.

Requirements for defoliation efficiency. Cooperative research has made many advances relative to the best time to defoliate and has shown just which weather and plant conditions are needed for efficiency. From one defoliant in 1947, suitable only for the dew belt, there are now seven available defoliants, some of which are efficient in the absence of dews. Much has been learned about proper timing, about the specific weather needed, and about the plant condition most conducive to defoliation. Annual published reports of progress keep research agencies, industrial concerns, and farmers advised relative to all advances and also present guides for use of each defoliant within each of the different areas.

F. Some Additional Work Needed

Additional studies of liquid fertilizers and application equipment particularly with anhydrous ammonia and pesticides are necessary to remove some of the present hazards and to make more efficient use of the materials. While some work is under way on equipment for applying pesticides, the heavy damage during the current year emphasizes the need of speeding up such research. Seedbed preparation studies in the different major soil types should be made throughout the cotton area. Previous studies on one soil type indicate yields can be increased and labor requirements reduced by judicious selection and use of tillage equipment. Planting studies to reduce the need of blocking, and also to facilitate harvesting, are needed and cultivation studies should be amplified to more effectively combat not only the common weeds but the troublesome grasses. Harvesting studies should be enlarged to permit the development of a low-cost mechanical harvester for use of the small farms.

Basic principles of defoliant-leaf reaction. There is a need to determine why atmospheric condition and plant growth status effect degree of defoliant absorption by the leaf.

New defoliants needed. The extreme efficiency of some non-practical defoliants (such as ethylene) indicates that practical chemicals of greater efficiency may be found through intensive basic study of type compounds.

CROSS REFERENCES - PRODUCTION

(For work in cooperation with States on regional projects S-1 and S-2, see Chapter 39.)

For additional information on subjects reported on in this chapter, see also;

BAE No. a-1-4, Chapter 24, risk and insurance.
BEPQ No. c-1,2, & 3, Chapter 35, pink bollworm and Thurber's weevil control.
BEPQ No. I-e-8, Chapter 31, white fringed beetle investigations.
BEPQ No. 1-m-3, Chapter 31, insecticide residues.
BEPQ No. I-m-1, Chapter 31, treatment of plants and commodities regulated by pink bollworm quarantines.
BEPQ, White fringed beetle control, Chapter 35.
BPISAE No. b-11-2, Chapter 38, introduction and evaluation of plants including cotton fibers.
BPISAE No. b-11-3, Chapter 18, introduction and evaluation of specialty crops.
BPISAE - b-12-1, Chapter 31, nematode studies
BPISAE - d-1-4, Chapter 22, soil management and cotton root rot.
BPISAE-RM:b-48, Chapter 31, research on nematodes
BPISAE No. RM: b-57, Chapter 31, weed control investigations.
BPISAE, BEPQ No. RM:b-68, Chapter 30, equipment and formulations for insecticides
BPISAE No. RM:b-111, Chapter 38, introduction and testing of new plants, etc.
BPISAE No. q-22, Chapter 38, plant disease survey.
OES No. b-1-10, Chapter 38, plant introduction in Puerto Rico.

UTILIZATION INVESTIGATIONS ON COTTON LINT*

(BAIC - RRL-2-3, Subcommodity Project 1 - Federal-State - Regular Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To develop new and extended markets and outlets for cotton lint and products derived therefrom. The current work is particularly concerned with applied research on the mechanical and chemical processing of cotton to provide new and improved products, to develop new techniques and equipment, and to reduce the cost of manufacture. The practical objective of the research effort is to contribute to the improvement of the competitive position of cotton relative to other textile fibers and to other products. In addition, research on the fundamental chemical and physical properties and chemical modification of cotton lint is conducted to support the applied research and to provide basic knowledge for further applied research.

B. Currently Active Line Projects

RESEARCH PROJECT RRL-2-(3)-C-4 - CHEMICAL PROCESSING OF COTTON TEXTILES

RRL-2-(3)-C-4-1 - Preservation of cotton fabrics against decomposition caused by weather and micro-organisms. To increase the durability of cotton fabrics in outdoor service (tents, awnings, sandbags, cover cloths), by chemical treatments designed to protect them against the action of weather and of cellulose-destroying micro-organisms. This project has involved extensive cooperation with the U. S. Corps of Engineers and with the Quartermaster Corps in work on rotproofing and weatherproofing of cotton fabrics; with the Florida Agricultural Experiment Station in protective treatments for tobacco shade cloth; and with other government and industrial laboratories in developing standard testing methods.

RRL-2-(3)-C-4-2 - Imparting crease resistance and related desirable properties to cotton textiles. To improve the resistance of cotton goods to creasing and wrinkling by the application of special finishing agents such as film-forming resins. Surveys have shown the great economic importance to cotton apparel of crease resistance comparable to that of wool.

---

* A Commodity Project of one of the Regional Research Laboratories administered by the Bureau of Agricultural and Industrial Chemistry. Under Section B of this report, currently active Line Projects are grouped under their parent Research Projects, which correspond approximately in scope to the regular Work Projects of other Bureaus of the Department. Likewise, under Sections D and E, Research Projects are used as the basis for reporting expenditures in 1950, and outstanding accomplishments.

RRL-2-(3)-C-4-3 - Chemical processing of cotton yarns or fabrics on pilot plant scale. To produce chemically modified or treated cotton materials on a semi-commercial scale, thus making available adequate supplies for laboratory research and commercial evaluation, as well as affording opportunity to develop practical processing methods and to study costs, waste recovery, etc.

RRL-2-(3)-C-4-4 - Acetylation of cotton goods to make textile products with new and unusual properties. To investigate the fundamental chemistry involved in the acetylation of cotton and to develop practical commercial methods of applying this type of treatment to cotton fibers, yarns, or fabrics, thus producing cotton products that are highly resistant to rotting and to heat.

RRL-2-(3)-C-4-5 - Mercerization characteristics of cottons of different varieties and growths. To determine the response of new varieties of cotton to mercerizing and dyeing treatments such as are employed in regular commercial processing. A large part of this work is being done in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, the agency responsible for developing new cotton varieties.

RRL-2-(3)-C-4-6 - Development of heat resistant textiles by mercerization and related treatments of cotton fiber, yarn, and cloth. To produce by mercerizing and similar types of chemical processing cotton products of improved resistance to heat and therefore more suitable for use in articles such as tire cord, gaskets, and belting.

RRL-2-(3)-C-4-7 - Aminization of cotton goods to make textile products with new and unusual properties. To produce a cotton fiber with new properties by introducing amino groups into the cellulose molecule, so that the resulting material will possess useful ion-exchange properties, have affinity for acid wool dyes that do not react with ordinary cotton, and be capable of reaction with various special finishing agents such as crease-proofing and rotproofing compounds.

RESEARCH PROJECT RRL-2-(3)-F-1 - RELATIONSHIP OF CHEMICAL AND PHYSICAL STRUCTURE OF COTTON FIBER TO TECHNICALLY SIGNIFICANT PROPERTIES.

RRL-2-(3)-F-1-5 - Comparative microscopic properties of cotton and competitive fibers. To observe and record microscopical characteristics of different cottons, of new chemical fibers derived from cotton, and of competing natural and synthetic fibers with respect to fiber shape and to yarn and fabric onstruction, and the influences of chemical and physical modification on these properties. Such observations permit judgments to be made of mill performance, extent of modification in derived products, and sources of damage to individual fibers by different processing operations.

RRL-2-(3)-F-1-6 - Influence of chemical and mechanical treatments on certain physical properties of cotton fiber. Design of instruments and development of methods for evaluating dimensional and mechanical properties of cotton fibers, and the determination of changes in these properties as the result of chemical and mechanical treatments.

RRL-2-(3)-F-1-7 - Relation between moisture content and physical properties of different varieties and types of cotton. To compare the moisture content of cottons having different physical properties in order to investigate the relation between moisture content and such inherent properties of the cotton as maturity and non-cellulosic impurities. One aim of this project is to find some method for estimating important physical properties, such as eleasticity, which cannot be measured directly.

RESEARCH PROJECT RRL-2-(3)-F-2 - IMPROVEMENT OF COTTON FIBER PROPERTIES.

RRL-2-(3)-F-2-2 - Structure of organic compounds in relation to the water repellency they impart to cotton textiles. To determine the relationship between the chemical structure of certain types of organic compounds and their ability to repel water with the aim of developing more satisfactory water repellent finishes for cotton fabrics.

RESEARCH PROJECT RRL-2-(3)-F-3 - COLLOID PROPERTIES OF THE COTTON FIBER.

RRL-2-(3)-F-3-3 - Determination of the size of the individual crystallites in cotton cellulose. A certain percentage of the molecules in the cotton fiber exist in an orderly arrangement of small crystalline bundles or crystallites. The size, number, and arrangement of these crystallites are known to influence the chemical and mechanical properties of cotton fabrics. This project is aimed at developing a quantitative method for determining crystallite size since there exists no satisfactory method at the present time. This will give a quick means of predicting the behavior of a smaple of cotton when only a small quantity is available, as in breeder stocks.

RRL-2-(3)-F-3-4 - Improving x-ray techniques for determining the crystallinity of cotton cellulose. Although the mechanical and chemical behavior of the cotton fiber depends on the crystalline structure of the cellulose making up this fiber, the methods for determining this crystallinity are unsatisfactory. It is the aim of this project to use the newly developed x-ray spectrometer for the determination of the degree of crystallinity of cotton cellulose.

RESEARCH PROJECT RRL-2-(3)-F-4 - NATURE AND PREVENTION OF DEGRADATION IN COTTON FIBER.

RRL-2-(3)-F-4-5 - Action on cotton of acids in alcoholic media. The action of acids on cotton is an important subject. When not controlled, it causes loss of strength, yet many of the commercial finishing agents require acid conditions for proper application. Also, acid degradation has been proposed as a method of measuring the degree of crystallinity and thus indirectly the useful properties of different types of cotton. It is known that the action of acids on other materials is different in methyl alcohol from what it is in water. The principal aim of this project is to investigate the action of acids in methyl alcohol upon cotton cellulose to determine whether the use of this solvent would have advantage over the use of water.

RESEARCH PROJECT RRL-2-(3)-F-5 - CHEMICAL DERIVATIVES OF COTTON FIBER.

RRL-2-(3)-F-5-4 - Imparting new properties to cotton by carboxymethylation. By reaction with chloracetic acid to produce a carboxymethylated cotton with new properties of increased water absorption or water solubility, and to investigate the usefulness of the products including their further chemical reaction. There is cooperation with several industrial concerns in applying this process to the commercial production of a soluble cotton yarn for special uses.

RRL-2-(3)-F-5-5 - Formation of cation-exchange material from cotton by reaction with certain high molecular weight derivatives of phosphoric acid. To develop laboratory methods of preparing highly phosphorylated cotton products and to determine the potentialities of the products as cation-exchange materials with the intention of providing new uses for cotton in the expanding ion-exchange field of chemical industry.

RRL-2-(3)-F-5-6 - Improving cotton fiber properties by treatment with isocyanates. To investigate the formation of cellulose urethanes by the reaction of cotton with isocyanate compounds and to determine the effect of such reactions on the physical and chemical properties of cotton fibers. The aim of this project is to obtain a modified cotton with improved properties, such as water repellency.

RESEARCH PROJECT RRL-2-(3)-P-1 - DEVELOPMENT OF COTTON PRODUCTS TO MEET SPECIFIC USE REQUIREMENTS.

RRL-2-(3)-P-1-2 - Experimental manufacture of cotton products for other research projects. To design and manufacture experimental cotton products having properties needed in the investigations described in other research line projects listed herein.

RESEARCH PROJECT RRL-2-(3)-P-2 - GENERAL RELATIONSHIPS BETWEEN FIBER, YARN, AND FABRIC PROPERTIES.

RRL-2-(3)-P-2-1 - Influence of cord construction on tire cord properties. To determine the effect of twist and number of strands in cotton tire cord on its tensile strength, elongation, and fatigue life, as a basis for developing improved types of cotton tire cord. The evaluation of the cord by means of laboratory tests is carried out in cooperation with tire cord manufacturers. Under a formal cooperative agreement a tire manufacturer is conducting practical evaluation tests by manufacturing tires using experimental cords and determining tire performance on a test wheel.

RRL-2-(3)-P-2-2 - Effect of fiber structure and strength on processing techniques and physical properties of resultant textiles. To determine the influence of fiber strength on the physical properties of cotton yarns and other products, so that cotton breeders can give this property proper consideration in their breeding programs and cotton spinners will be aided in selecting cottons having the strengths required for specific purposes. This work is conducted under formal cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

RRL-2-(3)-P-2-3 - Effect of fiber fineness on processing techniques and physical properties of resultant textiles. To determine the influence of fiber fineness on processing techniques, appearance, strength and other physical properties of yarns and fabrics to guide cotton breeders and supply spinners with information that will assist them in selecting cottons to meet the requirements of specific end uses. This work is conducted under formal cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

RESEARCH PROJECT RRL-2-(3)-P-3 - NEW AND IMPROVED COTTON PROCESSING MACHINERY AND TESTING EQUIPMENT.

RRL-2-(3)-P-3-5 - Development of a machine for opening lint cotton for textile processing. To develop new and improved equipment for opening and fluffing baled cotton, in order to increase trash removal in the mill by conventional textile cleaning machines.

RRL-2-(3)-P-3-6 - Miscellaneous short-time machinery and apparatus developments. To develop new equipment, or modify existing equipment, needed in connection with research on increasing cotton utilization. This project covers short-term investigations not requiring extended effort on any one development.

RRL-2-(3)-P-3-7 - Development of new weaving equipment. To develop a practical attachment for existing cotton-textile looms to permit weaving extremely dense fabrics that will have materially improved resistance to penetration by wind and water and therefore a wider field of utilization.

RESEARCH PROJECT RRL-2-(3)-P-4 - UTILIZATION OF COTTON AND COMPETING FIBERS AND PRODUCTS.

RRL-2-(3)-P-4-1 - Miscellaneous short-time surveys and appraisals on the utilization of cotton and competing fibers and products. To secure, analyze, and interpret economic and technological information to guide cotton utilization research. Certain phases of this work have been done in cooperation with the National Cotton Council.

RRL-2-(3)-P-4-2 - Surveys and appraisals on the use of cotton and competitive products in tire cord. To secure, analyze, and interpret technological and economic information relative to the utilization and performance of cotton and competitive products in tire cord.

RESEARCH PROJECT RRL-2-(3)-P-5 - PROCESSING ORGANIZATION AND TECHNIQUES AS THEY AFFECT QUALITY AND MANUFACTURING COSTS.

RRL-2-(3)-P-5-1 - Draft proportionment on long-draft roving frames for maximum roving uniformity. To determine the most efficient distribution of draft ratios on various types of long-draft roving frames to improve machine performance and to obtain maximum product uniformity in processing medium- and short-staple cottons.

RRL-2-(3)-P-5-2 - Effect of high-drafting roll speeds on drafting at the drawing processes on the quality of cotton yarn. To determine the practicability of employing higher-than-usual roll speed in the drawing process as a means of reducing manufacturing costs while improving or maintaining the quality of the yarn produced.

RESEARCH PROJECT RRL-2-(3)-A-4 - ANALYTICAL, PHYSICAL CHEMICAL, AND PHYSICAL INVESTIGATIONS OF COTTON LINT.

RRL-2-(3)-A-4-1 - Analytical, physical chemical, and physical investigations of cotton lint and cotton lint products. To assist the investigations described in other line projects of this report in the following ways: (a) by providing miscellaneous analytical services, physical chemical measurements and research services, specialized physical measurement services, and textile testing services; (b) by improving existing, and developing new, evaluation methods; and (c) by obtaining data on chemical composition and physical properties.

RRL-2-(3)-A-4-5 - Physical chemical investigations of the cellulose-water relationships in cotton. To investigate the nature of the relationship between water and the cellulose in cotton. To assist in improving cotton textiles with respect to water resistance by use of physical chemical techniques and principles such as those for determining nonfreezing water and porosity.

RRL-2-(3)-A-4-7 - Noncellulosic constituents in raw cotton fiber To assist in the solution of the problems connected with the processing of cotton by determining the noncellulosic constituents present and by determining the amounts of these constituents as influenced by such factors as variety of cotton and weathering before picking.

RRL-2-(3)-A-4-11 - Lubrication of tire cord. To improve the performance of cotton tire cord at elevated temperatures by the use of lubricants. The treatments have been evaluated through the informal cooperation of several tire manufacturers.

C. History and Evolution of this Work

Studies on the utilization of cotton were initiated on a very limited scale in the Department of Agriculture about 1927, following enactment of legislation by the 69th Congress, authorizing and directing the Secretaries of Agriculture and Commerce to conduct scientific research on cotton with a view to extending present uses and discovering new uses. The studies were of an economic nature until 1929 when a cooperative agreement was entered into with the North Carolina State College to use its textile equipment for processing research on developing new cotton products. This program of economic and experimental work in the Bureau of Agricultural Economics continued to 1939. Most of the work, however, was concerned with the acquisition of reliable information on the quantities of cotton consumed in hundreds of different end uses. With a view to broadening the outlets and expanding utilization of cotton and other crops, Congress in 1938 authorized the establishment of the four regional research laboratories of the Bureau of Agricultural and Industrial Chemistry. Following a nation-wide survey to ascertain the research then underway and to determine the type of research which should be conducted, a program of fundamental and applied nature was undertaken on the chemistry and utilization of cotton and cotton products.

D. Funds -- Annual Expenditures

Expenditures on utilization research on lint cotton in the Bureau of Agricultural Economics during the period 1927 - 1939 averaged about $30,000 annually.

During the 1941 - 1949 period annual expenditures on cotton in the Bureau of Agricultural and Industrial Chemistry ranged from $158,000 in 1941 to $671,000 in 1949, and averaged $520,000. The expenditure in 1950, amounting to $646,500, was apportioned among the different research projects, as follows: C-4, $180,000; F-1, $41,000; F-2, $30,500; F-3, $51,000; F-4, $30,500; F-5, $51,000; P-1, $22,000; P-2, $28,000; P-3, $53,000; P-4, $15,000; P-5, $29,500; A-4, $115,000.

E. Examples of Outstanding Accomplishments

RESEARCH PROJECT RRL-2-(3)-C-4.

Preservation of cotton fabrics against decomposition caused by weather and micro-organisms. Rotproofing treatments formulated and applied to standard army cotton sandbags were shown in comparative exposure trials to extend the useful life of the bags approximately 20 times beyond that of bags made from untreated cloth.

The technique of accelerated soil burial testing that was developed to evaluate rotproofing treatments is incorporated in current Army and Federal testing specifications. This work was carried on intensively during World War II in cooperation with the U. S. Corps of Engineers, and contributed significantly to the successful procurement by that agency of approximately 250,000,000 yards of effectively protected fabrics.

Treatment of tobacco shade cloth lead chromate, a process now commercially available, was shown by field trials conducted in northern Florida to make possible at least one extra season's use of the fabric.

Chemical processing of cotton yarn or fabric on pilot plant scale. Work on this project has shown that chemical modification of cotton materials by such processes as acetylation, aminization, and phosphorylation, can be carried out successfully with standard cotton textile finishing machinery. Many hundred yards of medium and heavy weight fabrics have been processed in this way to supply ample material for research in the laboratory for evaluation tests by interested industrial firms. Considerable quantities of cotton yarns have also been handled, and adaptation of existing equipment has made possible the successful treatment of cotton in lint form, including the recent partial acetylation of fiber for special use in quilted garments required for the Armed Forces.

At the request of the Research and Development Laboratories of the Philadelphia Quartermaster Depot, U. S. Army, these pilot plant facilities are now engaged in treating several thousand yards of cotton fabrics with selected fungicides and a water repellent in closely controlled concentrations. This work is being done in cooperation with extensive field exposure trials of the treated fabrics

Utilizing the same equipment as that employed for regular finishing procedures, it has been possible to convert low grade cotton osnaburgs and bag sheetings into useful and attractive fabrics that have shown excellent wearing qualities as dress goods and household furnishings. This development opens new uses for low grade cotton products and enhances their potential commercial value.

Heat and rot-resistant cotton goods made by partial acetylation. The excellent mildew- and rot-resisting qualities of this chemically modified cotton have been demonstrated in many practical tests. Yarns and fabric samples retained the greater part of their original strength through months of exposure to conditions of mildew and soil-contact rotting that destroyed untreated cotton in one week. Tests carried out on the coast of North Carolina have shown this product to be equally resistant to marine organisms. Fish net twine made from partially acetylated cotton retained 85 percent of their original strength after eight months of continuous immersion in salt water, while untreated cotton twine disappeared after one month and the best type of tarred twine was destroyed in six months.

This product also possesses unusual resistance to heat. Practical trials in commercial laundries have shown that roll and press table covers made of partially acetylated cotton fabric last 4 or 5 times as long as untreated cloth of similar construction. A number of industrial firms are studying the process, with a view to commercial production. It is anticipated that acetylated cotton may also go into markets not now served by cotton, and thus expand end use and consumption. Two industrial concerns are considering the manufacture of acetylated cotton.

Mercerization characteristics of cotton. Of outstanding importance to the cotton textile industry is the present intensive development of new and better varieties of cotton. The complete evaluation of a new variety requires, among other things, a knowledge of the manner in which it responds to mercerization -- a treatment widely used in cotton finishing. Since only limited amounts of the new cottons are grown at first, the quantities of yarns and fabrics available are usually insufficient for commercial trials and investigation of their mercerizing properties must be made on laboratory scale. Under this project special equipment has been devised to permit the mercerization of yarn samples with closely controlled conditions and automatic accurate recording of the tensions developed in the yarns during treatment. The lustrous properties of the yarns can then be estimated by both visual and instrumental means. This method has been used successfully to determine the mercerizing properties of two new irrigated California cottons, in comparison with a standard rain-grown variety, and is available for the examination of new varieties as they are produced. Thus the new technique has accelerated the research on new varieties of cotton.

A comparison of commercial bleaching methods. A detailed study of the processing steps employed commercially in desizing, singeing, kier-boiling, and bleaching a selected cotton sheeting showed the effects of these steps on the color, strength, and chemical composition of the fabric. This investigation made clear the safe limits of operations for the different bleaching methods employed. These results are of definite value to the industry.

Improved cotton bandage fabric. A semi-elastic all-cotton bandage fabric produced during World War II met with such approval in hospitals and clinical tests that it was necessary to prepare approximately 30,000 unit rolls of this bandage to meet the demand of a local Navy hospital. The bandage is outstanding for mild pressure dressings and it permits movement of bandaged joints without restricting circulation. It was particularly effective in cases involving bone surgery, its special elastic properties in this use being considered by surgeons to excel those of any other obtainable bandage. Commercial production of this article was considered by bandage manufacturers, but has not yet been actually carried out.

New cotton products by chemical modification. New and useful properties are imparted to cotton materials by chemical treatments which unite different groups with the cellulose molecule and thus change its composition without destroying the fibrous structure. Several of these chemical treatments have been carried out successfully on both laboratory and pilot plant scale with cotton fiber, yarns, and fabrics. There have been produced in this way, in addition to acetylated cotton, amino compounds of cotton, phosphate compounds, and cotton containing carboxymethyl groups.

One interesting result of such modifications of cotton is the change usually caused in its dyeing properties. The aminized product, for example, not only dyes deeper with the ordinary direct cotton dyes than does normal cotton, but also shows affinity for the brighter colored acid wool dyes with which the latter does not normally react. This suggests the possibility of obtaining a new range of attractive colors on cotton textiles.

Another striking property of these new cottons is the ion-exchange capacity several of them possess. This means that the modified cotton can remove traces of acids, alkalies, or metal compounds from solutions or gases in the same way that certain zeolites and synthetic resins operate to remove dissolved minerals in water softening processes. There appears to be considerable promise that these ion-exchange materials, in fiber or fabric forms, will find commercial use.

Additional useful properties of chemically modified cotton products are described under Research Projects F-2 and F-5.

RESEARCH PROJECT RRL-2-(3)-F-1

Single-fiber strength tester and other new techniques. A single-fiber tester for determining the tensile and elastic properties of individual cotton fibers makes available an important means of evaluating basic physical properties. It is a valuable tool in associating the properties of fibers with those of yarns and fabrics made from them. This is one of a variety of techniques developed which permit the acquisition of more complete knowledge of the intimate basic physical properties of cotton. Other such techniques include improved methods of measuring bundle strengths of fibers, an improved instrument and techniqe for measuring flexural fatigue of cords, and several microscopical methods for determining differences in the behavior of different cottons.

Nature of fiber lumen contents. The proteinaceous nature of the contents of the cotton fiber lumen (central cavity) has been definitely established, and several of the constituent amino acids have been identified. This fundamental information will have considerable value in purification processes of cotton and of modified cotton. The work illustrates the type of basic study that is a necessary prelude to advances in applied research.

RESEARCH PROJECT RRL-2-(3)-F-2

Improving the permanent flame resistance of cotton. Cotton cloth cannot be made completely fireproof, but it can be made resistant so that it will not continue to burn when the source of flame is removed. Several methods of improving this quality of cotton have been developed although none of them are entirely satisfactory.

The first method developed produced a permanent flame resistant finish but was too expensive for commercial application. A second process developed was less expensive and is suitable for outer garments and industrial fabrics. The second treatment is quite fast to laundering and has an excellent "hand" even with light fabrics. Public service patents have been obtained on both these processes.

Treatment of cotton with phosphoric acid derivatives produces a flame resistant product but is generally accompanied by loss of fabric strength. This disadvantage was reduced by the use of new phosphoric acid derivatives which react with cotton under less severe conditions of heat and acidity. The phosphorus-containing cottons also have other desirable properties which have been mentioned under Research project RRL-2-(3)-C-4.

Water repellency test. A method has been developed which measures differences in the water repellency of textile finishes. By this method the finish is tested not against a series of aqueous solutions having different surface tensions. Finishes which are wet only by solutions of low surface tension are more repellent to water. This technique permits a more accurate evaluation of water repellent finishes than is possible with other methods.

RESEARCH PROJECT RRL-2-(3)-F-3

Methods of evaluating ultimate utility of cottons. While cotton is sold on the basis of fiber length and arbitrary grade standards, its ultimate utility is determined by a variety of properties which are difficult to measure on small samples. It would be of advantage to purchasers of cotton to have additional and significant evaluation tests. It is also of particular importance to the plant breeder to have evaluation techniques which are suitable for very small samples of cotton. Methods developed here for evaluating the fine structure of cotton are suitable for this purpose. For the determination of the average length of the molecule, improved methods have been developed for the determination of the viscosity of cotton cellulose dissolved in certain complex solutions with copper. For the determination of the degree of crystallinity of cotton cellulose a useful method, involving the action of acids, has been devised. The swelling of bulk cotton with water has also been correlated with its fine structure and mechanical and chemical behavior.

RESEARCH PROJECT RRL-2-(3)-F-4

Action of heat on cotton tire cord. As one means of predicting the behavior of cotton cords in tires, the effect of heat on the cord was investigated. Studies were carried out on bare cords and on cords in various stages of tire manufacture. Rayon was found to degrade more than cotton from the effect of heat. A rubber coating on the cord provides some protection against degradation.

Reduction of light sensitivity of cellulose-ether plastics and finishes. Studies on the action of methyl alcohol and acid on cotton have shown that the reaction product is more stable chemically than when water is used instead of alcohol. This information is being used on a trial basis by a large chemical company to produce cellulose ethers of improved stability to air and light. It is of value to the cotton industry since these ethers are made from cotton linters and are used in finishes for cotton textiles.

RESEARCH PROJECT RRL-2-(3)-F-5

New process for stabilizing guncotton. In research during World War II on the suitability of cut-staple cotton as a supplement for linters in the manufacture of smokeless powder, a new process was developed for stabilizing nitrocellulose, on which two public service patents have been granted. The essential feature of this process is the use of small quantities of ammonia in the wash water, after the nitration step. Adoption of the ammonia stabilization process reduces the time to one third that formerly needed for the manufacture of guncotton. There is a corresponding saving in cost, and -- of greater importance in wartime -- a sizeable decrease in the facilities and of the area required for a nitration plant. Large-scale tests by the Navy Department have shown that the new process has promise.

Water-soluble cotton yarn. A new product has been developed which is arousing considerable interest among industries in need of an easily removable scaffolding yarn for knitting and weaving operations and for certain uses in food packaging. This product is obtained by treating cotton yarn with two inexpensive chemicals, chloroacetic acid and alkali, to form carboxymethylated cotton. The treated yarn retains its original appearance and strength but readily dissolves in water. It is the first known example of a soluble cotton yarn with good dry strength. Several firms are considering its production.

Cotton goods given a milder carboxymethylation treatment are not soluble but do possess increased reactivity, water absorption, and ion-exchange capacity. The ion-exchange capacity of these materials has been discussed under Research Project RRl-2-(3)-C-4. Fabrics of this type has been produced experimentally by the textile industry using data obtained in the above research.

Standard cotton bale covering. A satisfactory light-weight cotton bagging was developed as a substitute for the coarse heavy-weight jute bagging commonly used as a covering on American cotton bales. This cotton bale cover has the following advantages over the coarse jute bagging: (1) economies in transportation; (2) cotton lint does not adhere to cotton bagging as tenaciously as it does to bagging now generally used; (3) no contamination of cotton with other fibers; (4) greater re-use value; (5) increased consumption of cotton; and (6) tends to obviate the costly practice of challenging and taring American cotton in spinners' markets. Approximately 44 million yards, equivalent to about 77,000 bales, were purchased under diversion programs to make the new bagging, which stood up satisfactorily under all service conditions. The present practice of marketing cotton on a gross weight has discouraged the use of light-weight covering. This circumstance, coupled with the fact that cotton bagging is usually more expensive than jute bagging, has prevented the wide-spread use of cotton bagging. This research will materially assist in capturing a potential market for 125,000 bales of cotton annually when the practice of selling cotton on a net weight basis is adopted.

Low-stretch cotton twine for postal service. Ordinary cotton twine is unsatisfactory for tieing letter mail because it stretches and allows the letters to become loose and the package to fall apart. A low-stretch cotton twine developed for the purpose proved entirely satisfactory under service conditions. Considerable quantities were used by the Post Office Department during the years when the difference in price between cotton and jute was not excessive.

Probeable cotton bags for free-flowing seed. Since conventional cotton fabrics are not entirely suitable for packaging free-flowing seed because of the need for drawing samples from the bags, a new and more suitable fabric has been designed. The yarns of the new fabric can be easily displaced by the sampling probe, but after sampling, the displaced threads readily return to their original positions. Bags made from the new fabric have been used for marketing considerable quantities of free-flowing seed, such as Austrian winter peas and hairy vetch. A large bag manufacturer has used the results of this development in producing a bag having several probeable stripes. This stripe-bag was well received by seed distributors, and sizeable quantities of cotton are consumed in this use.

Duplex cotton bags. A cotton bag having an open-mesh section for inspection of its contents, and a close-mesh section for effectively carrying the brand name, was developed and a public service patent obtained. This product was well received by the trade for packaging citrus fruits and certain types of vegetables and nuts. More than 2,000,000 bags of this type were used during the first two years. The popularity of the bag increased steadily until it accounted for 63,000,000 yards of fabric in 1946, the last year for which figures are available. This development has contributed materially to making cotton bags more competitive with similar type bags made of twisted paper.

Improved cotton tire cord. Varieties of cotton differ widely in properties such as strength and fineness. Such variation affects the physical properties and serviceability of yarns and cords. In order to determine which cottons were most suitable for use in tire cord, five commercial varieties, selected for their strength and staple length, were investigated. Cords made from each variety were fabricated into tires, which were fleet-tested by both the Army and the Government Tire Testing Fleets. As compared with commercial tire cord, two varieties (Wilds 13 and SxP) were found to give superior performance in tires, and one other variety (Stoneville 2-B) gave excellent service. This study demonstrated the feasibility of obtaining superior tire cord performance through the careful selection of cottons.

RESEARCH PROJECT RRL-2-(3)-P-2.

Effect of fiber fineness on yarn quality and production rates. Two important properties, fiber fineness and fiber length, are inherently highly correlated; hence it has been difficult to assess independently the contribution that each makes to yarn strength and spinning performance. The development of a technique for cutting cottons of different lengths and finenesses to the same length pattern has made it possible for the first time to evaluate independently the effect of fineness. Studies of the effect of this property on yarn quality and processing techniques showed: (1) fiber fineness had little or no effect on yarn elongation; (2) fine-fibered cottons gave yarns of higher strength than did coarse-fibered cottons in all the counts spun (16s, 24s, 36s, and 50s), and with the higher counts the differences were more marked; (3) fine cottons responded much more quickly to twist than did coarse cottons, that is, the yarns attained maximum strength with lower twists, and after reaching maximum strength lost strength much more rapidly with increases in twist than did yarns spun from coarse fibers.

These results will guide cotton geneticists in giving fiber fineness proper consideration in their breeding selections, and will aid manufacturers in the selection and processing of cottons for specific end uses.

Influence of cord construction on tire cord properties. Serviceability of a cotton cord for use in pneumatic tires is affected not only by the fiber properties of the raw cotton used, but also by the turns per inch of twist in its component parts, and the number of strands used in making up those parts.

Fifty-four cotton tire cords with different combinations of twist in the component parts, were exhaustively studied. The investigation was conducted with the aid of an electronic device of high precision for measuring physical properties not normally determined. As a result of this study, mathematical expressions were derived showing the relationships of tensile strength, stiffness, and flex life with various combinations of twists; and the relative effect of the addition of one turn per inch of twist in the component parts was established. A mathematical formula was developed as a guide for selecting proper twist combinations for the construction of cords with the desired tensile strength and other physical properties needed for a more serviceable cotton tire cord.

High capacity cotton cutter. The possibility of a serious shortage of linters during World War II showed the need for equipment for cutting surplus low-grade short-staple cotton into lengths suitable for the preparation of chemical cellulose -- a material vital to the production of high grade smokeless powder. The Armed Forces required large amounts of nitrocellulose from cotton for use in propellants for rocket and artillery shells. The successful development of a cotton cutter of 10 tons per hour capacity gave assurance that an adequate supply of such powder would be available, if needed, for this or any future emergency.

Aside from its importance for military uses, the machine has considerable promise for peacetime industrial applications. It has been successfully used by a manufacturer of specialty cellulose pulps for paper and may open a new field of use for cotton waste. The equipment also has potential use for cutting fibrous residues from agricultural crops.

New type cotton opener. Going into industrial use at textile mills is a radically different and more efficient machine which opens and fluffs matted masses of cotton and puts it in a condition like that of loose lint before it is baled at the gin. With exceptionally high capacity for its size, this small, compact opener permits better cleaning of mechanically harvested and other trashy cottons in textile mills. Despite its high-speed operation, the new opener does not increase the formation of neps (entangled fibers), nor affect the grade or strength of yarns. The machine is a valuable contribution to the textile industry, because cleaning of cotton is becoming more important as the market receives increased amounts of trashy cotton due to mechanical harvesting. About 16% of the 1950 cotton acreage was mechanically harvested.

Within one month after public announcement of the opener, numerous domestic and foreign textile manufacturers expressed interest in installing this equipment, and a textile machinery manufacturer is preparing to produce the opener for sale. A manufacturer of cotton textiles is constructing an opener for use in their plant under a non-exclusive license. A special feature of the opener -- a new system of removing lint cotton from rotating toothed cylinders -- has attracted the interest of the cotton-ginning industry.

Constant-tension tire-cord stretching machine. Cotton cord for automobile passenger car tires is put through a stretching process in order to reduce elongation and increase strength. Improved equipment for stretching cord has been developed and patented. With it a more uniform cord has been produced, thereby improving the competitive position of cotton. Offered to industry, the new machine was used experimentally by a number of tire cord and belting cord manufacturers. Its industrial adoption has been retarded because manufacturers hesitate to invest in new equipment for processing cotton cord since rayon, largely due to its lower price, is rapidly replacing cotton in passenger car tires.

Improved method of measuring textile product uniformity. Significant improvements have been made to increase the accuracy and speed of measuring the physical properties of textile products. Stimulated by an idea proposed by a textile manufacturer, a practical method was devised to replace the graphic recording device on a conventional textile-uniformity sliver-testing machine with a system of electrical counters which automatically tabulate the test data and put it into a form to facilitate statistical analysis. Not only is the new method twice as fast as the usual strip-chart method, but it provides many more measurements on the same length of textile product to give increased accuracy of results. The electrical counting device, a valuable tool for textile mills and research laboratories, has a number of applications in improving the quality of cotton textile products.

Electronic Drying of Textile Products. Application of modern scientific methods of generating high-frequency radio waves resulted in the development of equipment for converting this type of electrical energy into heat energy within cotton textile materials. A basic design of apparatus was patented for electronic drying of cotton yarn, cord or fabric in a continuous process as compared with batch processes of this method previously used. The new apparatus is more efficient than any other equipment of similar nature. Adoption by the textile industry for improving product quality is dependent on reductions in the cost of electrical power for electronic high-frequency heating.

Development of a new machine for slashing cotton textile warps. A new type slasher has been developed that represents a progressive step in designing textile equipment on modern scientific principles. The machine was designed to produce higher quality sized warps needed for more efficient weaving. Weaving is an extremely important factor in textile mill operations, representing upwards of 40 percent of manufacturing costs. The new slasher provides more uniformly sized and dried yarns, with closely controlled elongation properties. It has several outstanding features, such as a novel method of cooking and applying the size solution, an original design of radiant-convention oven, with overall drying efficiencies approaching 80 percent, and an electronically controlled direct current multi-motor drive system providing automatic regulation of yarn tension. The slasher is covered by four patents pending or issued.

Apparatus for evaluating cotton textile warps. Evaluating warp size formulations and warp quality usually requires weeks of testing on many looms in a textile mill. The construction of a simple apparatus which simulates the action of a loom has provided a successful method for evaluating size solutions and slashing techniques within a few hours' time at little expense. Valuable to industry as well as research, the new apparatus fills a definite need for a quick means of determining sized warp quality.

Loom attachment for weaving dense fabrics. The development of a commercially practical attachment permits the use of conventional textile looms for weaving cotton fabrics having an unusually large number of filling threads per inch. The new tightly-woven fabrics are extremely water- and wind-resistant, and make available a greatly improved material for outer wearing apparel, certain military fabrics, and for industrial uses such as tarpaulins and tentage. The attachment is simple and inexpensive to construct, and does not affect the operation of the loom with respect to weaving normal fabrics.

RESEARCH PROJECT RRL-2-(3)-P-4.

Research to determine the economic and technological factors which influence the consumption of cotton in specific end-use markets. In 1927 the Department initiated a continuing program of economic research on cotton utilization. Detailed studies were made of selected end-use markets to determine the quantities, grades, and staples of cotton consumed in industrial, clothing, and household uses and to provide information on competitive factors which influence those markets. In 1940, this type of cotton research was geared to the needs of the Bureau, and has been of definite aid in selecting specific projects such as tire cord development and cut lint for nitrocellulose.

Consumption of fibers and cotton's competitive position. Comprehensive basic data on the consumption in the United States of economically important natural and man-made fibers have been brought together in a detailed report entitled "Trends in the Consumption of Fibers in the United States, 1892-1946." In addition to this report, two studies, one entitled "Survey of Development and Use of Rayon and Other Synthetic Fibers," and the other "Synthetic Fibers and Paper as Competitors of Cotton," have been published. These reports have served as a guide in the conduct of research on the utilization of cotton by bringing together and presenting in simple form the gist of a large amount of widely scattered information, both published and unpublished. The information has shown where cotton is losing markets, and has pointed the way toward research which would aid cotton in maintaining its competitive position with man-made fibers and paper.

Survey of postwar agricultural and economic problems of the cotton belt. A short-term economic research study on "Postwar Agricultural and Economic Problems of the Cotton Belt" was participated in with other agencies of the Department of Agriculture, with land-grant colleges of the South, and with other organizations interested in the South. This project, which was one of the most comprehensive efforts yet made to bring together information relating to the economic problems of cotton and southern agriculture, included cotton goods production, distribution techniques, costs, and margins; the competitive position of cotton in specific end-use markets; and the present status of synthetic textile products. This cooperative econmic study, sponsored by the Marketing Subcommittee of the House Committee on Agriculture, gave a clearer understanding of the competition faced by cotton and was of value in the formulation of general research, merchandising, and other programs on cotton.

The market for cotton textiles in bags was discussed in a report which analyzed the production, consumption, demand, price, and quality of textile bags in general and cotton bags in particular.

The analysis showed that cotton's initial price disadvantage with relation to competitive materials can best be overcome through continued research and promotion of quality bag fabrics having desirable re-use and salvage values. Since this report was issued, the textile bag industry has increased the use of cotton through "pretty print" fabric designs in feed and fertilizer bags which can be utilized in wearing apparel and household furnishings.

RESEARCH PROJECT RRL-2-(3)-P-5

Improved guide for draft ratios on long-draft roving frames. The draft obtained on textile roving frames is determined by changing the gears on the machine. The use of commercially available draft-guide tables for selecting the gears resulted in non-uniform roving, which lowered the quality of the spun yarn. Improved draft ratios have been worked out for long, fine-fibered cotton on long-draft frames which have been sufficiently adopted by industry to demonstrate the practical utility of the guide. Many mills have reported that its use resulted in higher quality products and improved machine efficiency.

Improving quality and lowering yarn cost by better draft distribution. Manufacturing medium-coarse yarns with exceptionally high strength for a low twist was achieved through a carefully planned distribution of draft among the drawing, roving, and spinning processes. Yarns of this type were found to be particularly suitable for the manufacture of an improved tire cord. Knowledge gained from this study of draft distribution has made it possible to eliminate one drawing process in the manufacture of yarn, thus reducing processing cost without sacrificing quality.

RESEARCH PROJECT RRL-2-(3)-A-4

The major portion of the work under this project consists of analytical chemical, physical chemical, physical, and textile evaluation and testing services of routine or specialized nature for investigations conducted under the other line projects on cotton.

New and improved analytical chemical methods. To provide adequate means of determining the chemical composition and evaluating the properties of cotton and its products, existing methods have been improved and new ones have been developed. The methods developed include: Determination of copper in cotton textiles treated to prevent mildew; determination of acidity of textiles; determination of combined formaldehyde in organic compounds; determination of small amounts of sulfate in cellulose esters; determination of glycosidic methoxyl in cellulose derivatives; determination of ion exchanger capacity; determination of pectic substances in cotton; detection of honeydew on cotton; and detection of trace quantities of nitrogen.

These analytical methods are useful as evaluation tools in research and control in many organizations concerned with the properties and utilization of cotton.

Physical methods of evaluation. The evaluation of textiles has been aided by investigations on physical methods and properties. A method has been developed for determining the resistance of fabrics to wetting by use of tensiometer. Techniques developed for determining the pore size distribution show the influence of weave, ends per inch, and maturity of cotton on the porosity of fabrics.

Noncellulosic constituents of raw cotton. In adding to knowledge of the non-cellulosic constituents of raw cotton, which comprise from 4 to 8 percent of the dry substance and influence the physical properties of cotton, malic, citric, and oxalic acids and galacto-araban have been isolated and identified. The organic acids and ash alkalinity have been shown to be closely associated if pectic acid is taken into account. Both the acids and ash are reduced by exposure of cotton in the opened boll to weathering and to molds, resulting in the cotton becoming alkaline. These observations are leading to a consideration of the use of acidity measurements in sorting cottons for more even running in the cotton mill.

Physical properties of cotton tire cord. From a systematic study of hysteresis and related elastic properties of cotton tire cords of different types and constructions, it has been shown that superior cords should have the following elastic properties: high tensile -- to enable the use of less cord per tire; low hysteresis -- to produce a cooler running tire; low modulus -- to absorb sudden impacts in service; initial elongation -- sufficient for satisfactory manufacture of tires; and low growth rate -- to prevent undesirable increase in tire size.

F. Some Additional Work Needed.

Determination of the influence of varieties, growths, and processing methods on the dyeing properties of commercial cottons. The uneven dyeing of cotton yarns and fabrics in industry has long been a serious problem that usually means loss of production, the expense of rehandling, and a generally lower quality of finished goods. A better understanding of the various factors that influence the dyeing qualities of cotton materials would be of great assistance in improving this situation. Information should be secured on the dyeing characteristics of cottons of different varieties and growths, as well as on the effect that mechanical and chemical processing methods may have on these dyeing properties.

Evaluation of the effect of light on cotton textiles. The effect of natural and artificial light on cotton requires extensive investigation, since the destructive action of sunlight on cotton is a matter of great econimic importance, and the preparation of effective protective treatments requires a better understanding of the manner in which light energy operates to break down cotton cellulose. It would be a great advantage in work of this kind to have available sources of artificial light capable of causing a rapid breakdown of cotton like that produced more slowly by the action of natural light. The arc lamps now used for this purpose emit light that differs widely from sunlight in quality and therefore does not produce the same effect upon cotton.

Effect of cotton fiber length on physical properties of yarns, fabrics, and processing rates. Fiber length is one of the principal fiber properties contributing to spinning quality. It is highly correlated with fiber fineness, and, therefore, its effects on yarn and fabric properties have not been clearly defined. In order to enable the selection of cottons possessing those fiber properties specifically suited to special end uses, it will be necessary to provide basic information about the effects of fiber length on yarn and fabric quality.

New machinery and methods for producing more uniform picker laps. The textile industry is agreed that the quality of textile products is more dependent on the uniformity of picker laps than on any other single factor. The uniformity problem is complicated by the fact that picker laps are produced by processing cotton through a long line of opening, cleaning, and picking equipment. The development of new equipment producing more uniform laps would materially enhance the quality of cotton textile products, and improve cotton's competitive position in relation to the uniform synthetic fibers.

Improved carding equipment. The cotton carding machine has certain inherent operational features that are known to cause drafting waves in the card sliver; nevertheless the carding machine is indispensable for textile processing. The machine in present use is essentially the same as was conceived more than 200 years ago, with minor improvements during the last 45 years. There is need for research leading to modifications or radical changes in carding equipment to produce more uniform sliver and thereby improve the quality of cotton yarns and fabrics.

Effect of fabric structure on physical properties of fabrics. Recent research has shown that fabric structure bears a direct relationship to the service life of fabrics used for work clothes. Research along similar lines should be continued with other classes of fabrics to determine exactly how fabric structure influences serviceability and possibly consumer appeal.

Effect of yarn variability on fabric quality. Little knowledge is available concerning the effect of yarn variability on fabric quality. It is well known that different types of fabrics require different degrees of yarn uniformity to make them satisfactory for consumer acceptance. It is conceivable that in many instances a higher degree of yarn uniformity is attained than is actually necessary, leading to over-refined quality controls and consequent higher operating costs. Therefore research is needed to determine what influence yarn variability has on the quality of fabrics and what degree of uniformity is required for different end uses.

Evaluation of new types of cotton obtained from inter-species crosses. The RMA Cotton Advisory Committee has given a high priority to research on processing new cotton from inter-species crosses. This recommendation was made on the basis of the recent development of new types of cotton having approximately 75 percent greater average fiber strength than the existing commercial cottons. Fiber strength is an important fiber property that contributes materially to yarn and fabric quality. It is necessary, therefore, to evaluate such cottons with regard to their special properties and to their suitability for specific end uses, particularly where high strength products are needed to compete with synthetic fibers.

Lowering the cost of the carding process. Approximately 3 percent of cotton lint processed is removed in the form of cylinder and flat strips during the carding operation. These strips consist largely of the same fiber lengths as those fed into the card. Their sale for about 60 percent of the initial cost of the cotton represents a substantial economic loss. The revolving, flat top card, because of its construction, lends itself to the re-use of flat and cylinder strips after only minor mechanical changes. Critical studies are needed (1) to develop means and techniqes for automatically and uniformly returning the flat and cylinder strips to the stock being carded, and (2) to determine the effect of using these strips upon yarn and fabric quality.

Influence of type of solvent used on the effectiveness of water repellent treatments. It has been observed that a given water repellent material, when applied to textiles from different solvents, produces widely different degrees of repellency. This may be due to the effect of the solvent on orientation of the repellent molecules, to the amount of repellent material taken up from the particular solvent, or to some still unknown cause. These factors should be investigated with a view to developing improved water repellent finishes.

Behavior of cotton products at low temperatures. Physical properties of most materials change markedly with temperature, yet little work has been carried out on low-temperature measurements of textile fibers. For both military and industrial purposes information is needed as to the effect of freezing and below-freezing temperatures on such fiber properties as elasticity, fine structure, and moisture and stress-strain relationships. These data are needed in developing cotton products for use in very cold climates.

New fibers from cotton by esterification. Previous work has shown that valuable properties can be imparted to cotton by partial acetylation of the hydroxyl groups in the cellulose molecule. This research should be expanded by reacting cotton with other acids, and the resultant textiles should be evaluated for potential uses.

Metallic derivatives of cotton cellulose. The cellulose of cotton is known to form complexes with certain metallic compounds which are of considerable interest to the textile industry. Several of the complexes with copper are soluble and are used in textile finishes and in control of degradation. The use of titanium compounds in flame-proofing cotton probably depends on complex formation as does dyeing with metallic compounds. Little is known about the properties of such compounds and research on this subject should contribute to the development of improved cotton products.

FUNDAMENTAL CHARACTERISTICS OF COTTON FIBER AS A MEANS OF DEVELOPING ENTIRELY NEW USES

(BAIC-RM:a-102-Federal - RMA Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To increase fundamental knowledge of the cotton fiber and its constituents by expanded research in the chemical and physical sciences upon these materials. This new research is directed specifically toward more effective use of the many valuable properties inherent in the cotton fiber and to improvement of those particular qualities that would increase the utility of the cotton fiber and in turn of the products made from cotton.

B. Currently Active Line Projects

RM:a-102-1 - Microscopical evaluation of fiber swelling. To determine the extent of swelling of cotton fibers when wet with water; whether varietal differences in swelling exist; whether degree of swelling depends on state of maturity of fiber; and to what extent swelling in water involves change in fiber shape. This information is basic to the utilization of cotton in all commodities in which change in dimensions due to moisture is a factor in either manufacture or use, and especially in water-resistant fabrics of the self-sealing type for military, agricultural, or apparel uses.

RM:a-102-2 - Changes in the cellulose of cotton fiber upon oxidation. To stabilize cotton fiber against oxidation and to discover new methods for eliminating or substantially reducing the deleterious effects produced by oxidation. Damage to cotton fibers due to oxidation is of two kinds: (a) that which is immediately apparent and (b) that which develops upon subsequent exposure to mild alkalies. In the cases of oxidation by periodate and neutral hypochlorite, chemical treatments have been found which reduce the extent of the second type of fiber damage; other types of oxidation are being studied with a view to discovering similar treatments or methods for protecting the fibers against oxidation when exposed to the oxidizing agent.

RM:a-102-3 - Chemical bonding of cotton fiber with resins for the purpose of producing new cotton products. To find processes for the bonding of resins to cotton for the purpose of imparting new and useful properties such as wrinkle resistance and water repellency.

RM:a-102-4 - Improvement of elasticity recovery in cotton fiber by chemical modification. To apply a combination of swelling treatments and chemical modification to cotton fiber and to study the effects of such treatments on the elasticity of the fibers. Selection is made of treatments that show promise of improving the relatively unfavorable elasticity behavior of cotton and thus provide a more adequate adaptation to the needs of industry with better service to the user, and ultimately an increase in net returns to the grower.

RM:a-102-5 - Energy relations in performance of mechanical cotton goods. To develop test procedures and equipment for measurement of expended energy in mechanical cotton goods, such as tire cord, and to correlate such measurements with other properties and service requirements and

RM:a-102-6 - Estimation of immaturity in cotton by means of dyeing. To develop a simple and practical mill test based upon differential dyeing by which to determine in any given sample of cotton the approximate amount of thin-walled, or immature, fibers present as compared with the amount of normally developed thick-walled fibers. Such knowledge permits direction of cotton entering the mill into the most suitable end products.

RM:a-102-7-(C) - Comparison of different methods of measuring the "drag" of cotton fiber. To determine the relative merits of different methods of measuring the "drag" of cotton fibers. Resistance of ginned cotton fibers to being pulled apart or drawn past one another is a property important to the evaluation of spinning quality of cottons. In comparative studies of different methods the effects of sample weight, gauge lengths, twist, and rate of loading are being investigated on various specially selected types of cotton. This research is being conducted by contract with a textile research institution.

RM:a-102-8-(C) - Application of special optical methods to a study of the deterioration of cotton cellulose. To investigate the possibility of applying infrared spectrophotometry to cotton cellulose and degraded cottons as a means of identifying the specific organic chemical groupings involved in the deterioration and following the changes which take place in them during deterioration. The National Bureau of Standards, Washington, D. C., is conducting this research with funds transferred from this Department.

RM:a-102-9-(C) - Development of an instrument to determine the tensile strength of cotton fibers. To design and construct a tester, and to develop the technique for its use, which will afford a rapid and accurate means of measuring the strength of cotton fibers. Experience has shown that the tensile strength of cotton fibers is one of the most important qualities of cotton and is a major factor in determining the utility of cotton for manufacture; it is therefore essential that measurement of this property be made quickly and with the best possible accuracy. This research is being conducted by contract with the University of Tennessee, Knoxville, Tenn.

RM:a-102-10-(C) - Surface properties of cotton fibers. To investigate the surface area, as measured by means of the gas adsorption method, with reference to related properties of cotton fibers as influenced by standard and experimental textile finishing processes such as wetting, drying, swelling, dyeing, finishing, and other processing treatments in order to provide information of value in developing improved cotton products. The National Bureau of Standards, Washington, D. C., is conducting this research with funds transferred from this Department.

RM:a-102-11 - Study of cotton cellulose molecules. To obtain fuller use of the properties of cotton cellulose both as a fiber and in solution, from fundamental investigation of its molecular behavior in solution. Cellulosic samples that have been subjected to various physical and chemical treatments, as well as those in their natural states, are examined by special physical techniques to determine the influence of particle size, shape, and distribution of particular fiber and solution characteristics.

RM:a-102-12 - Examination of shapes and swelling characteristics of cotton fibers. To obtain information as to the effectiveness of tension in changing both the cross-sectional and longitudinal shapes of cotton fibers, especially in connection with the swelling of the fiber in water. Change in fiber shape from that of a collapsed tube to that approaching a cylinder has been stated as a cause of the improved luster in mercerized cotton. If this condition could be induced by tension on wet fibers (without the physical modification inherent in the mercerization process) cotton might be enabled to compete more effectively in those areas of the textile market where sheen is a desirable characteristic.

RM:a-102-13 - The reactions of certain chemicals with cellulose. To react cyanuric chloride and its derivatives with cotton cellulose and to study the resulting products for useful properties such as increased strength, improved dyeing characteristics, and better resistance to mildew and rot.

C. History and Evolution of this Work

Limited research on the properties of cotton fiber to increase utilization began about 1927 in the Bureau of Agricultural Economics. About 1940, after the establishment of the Regional Research Laboratories, cotton utilization research was placed in the Bureau of Agricultural Chemistry and Engineering, and the program of investigations was greatly expanded. The scale of this effort was later judged to be too small by a special Subcommittee on Cotton of the House of Representatives, which held hearings on the research needs of cotton. As a result, this project on fundamental properties of cotton was approved in 1948, and funds were allotted from appropriations authorized by the Research and Marketing Act of 1946. Emphasis was placed on new fundamental data on fiber properties with a view to channelling cotton into those uses for which it is particularly suited, and on exploratory investigations of chemical treatments which change the basic nature of the cellulose in the fiber and thus impart new and improved qualities in cotton textiles.

D. Funds -- Annual Expenditures

During the 3 fiscal years this project has been active, namely, 1948, 1949, and 1950, the approximate annual expenditures have been $113,500, $94,600, and $158,700, respectively.

E. Examples of Outstanding Accomplishments

Estimation of immaturity of cotton by means of dyeing. The advent in the cotton manufacturing industry of a simple differential dyeing test that makes immediately evident the approximate amount of thin-walled, or immature, fibers present in any lot of cotton supplied a new method of quality control that has attracted attention wherever cotton is grown or processed. This test was devised in 1947 in research on cotton under regular runds. Recently applications of the test have been made under RMA funds, in cooperation with private firms, for classifying cottons and directing different classes to the most suitable end products. The test is also used by cotton brokers to insure the delivery of satisfactory lots of cotton to their customers. Application of the test in large-scale cotton manufacturing has resulted in the elimination of waste and a general improvement in the quality of cotton goods.

New basic data on properties of cotton fiber. Two distinctive advances have been made in acquiring new scientific data on properties of cotton fiber. One is the discovery of a simple chemical treatment for permanently reducing the proportion of crystalline cellulose in cotton fiber as a means of enhancing chemical reactivity and improving elastic recovery and other physical properties. The other advance is a technique of powdering cotton fiber and measuring its infrared light adsorption qualities, which provides the scientist a new research tool in determining the effect of heat on cotton and in developing new methods of increasing the ability of cotton to withstand heat.

Direct measurement of the cross-sectional area of cotton fibers in both wet and dry condition. A new approach to the production of improved water resistant cotton materials has been developed through better utilization of cotton's natural swelling in water. Exact data as to the extent of swelling of cotton fibers in water and differences in swelling between varieties of cotton were needed. By the method of measuring swelling developed under this project it was demonstrated that cotton fibers, regardless of variety or degree of development, increase in area on wetting by about 25 to 30 percent compared with twice that amount for flax and rayon. The new method is a distinct scientific contribution and is being used to determine the dimensional changes due to wetting of new chemically treated fibers including the acetylated, mercerized, carboxymethylated, ethylamine treated and aminized cottons.

F. Some Additional Work Needed

Influence of moisture and temperature on elastic properties of cotton and competitive textile fibers. Fundamental information is needed on the changes in physical properties of cotton and competitive textile fibers when subjected to moisture and temperature conditions simulating those in service performance of textiles. Preliminary results showed that the permanent reduction in strength and elongation of the fibers caused by elevated temperatures is accelerated by high moisture content. There was evidence that this degradation occurs at localized places along the fibers. Research on individual fibers and on yarns and fabrics should provide information of value in determining the effect of various artificial drying processes on the physical properties of cottons, particularly those harvested when moist.

Microscopical investigations of fundamental physical structure of the cotton fiber. Investigations with the optical microscope and the electron microscope on the various physical components of the cotton fiber, such as the primary wall, the cellulose layers of the secondary wall, and the canal (lumen), are needed to better understand the behavior of cotton fibers in technological operations. The structural features of these parts should be examined in an attempt to develop more explicit information than now exists on the interrelationship of the physical components and their contributions to the useful properties of the fiber.

Determination of ratio of crystalline to noncrystalline cellulose in cotton by magnetic measurements. The problem involves the measurement of the magnetic properties of various cottons and related cellulosic fibers to obtain an additional means of evaluating and assessing the ratio of crystalline to noncrystalline cellulose in these fibers. In preliminary studies, measured magnetic properties were shown to be significantly different for the various cellulosic fibers studied.

The introduction of highly reactive chemical groups into the cotton fiber, to serve as points for bonding of resins. Practical ways should be found for effecting this type of reaction, since it may prove to be a promising approach to the problem of producing permanently wrinkle-resistant cotton fabrics.

The effect of crease-resistant treatments upon the properties of cotton fibers. The effect of crease-resistant treatments on the fibers should be more fully investigated to supplement the work that has been done and is in progress on the application of such treatments to woven fabrics. There is still a lack of understanding of many of the fundamental properties that contribute to crease-resistance. A better knowledge of how and to what extent the mechanical properties of the fiber are affected by the conventional crease-resistant treatments should contribute greatly to the better development of such treatments.

Properties of low-crystalline cotton. That the low-crystalline cotton may have physical properties very different from those of ordinary cottons has been indicated by the results of certain preliminary tests. Extensive studies of cotton treated to reduce crystallinity should be carried out to get a complete knowledge of the physical properties of this new material, such as fatigue from flexing heat resistance, and elasticity recovery. Chemical properties, such as affinity for dyes, adsorption, and rate of acetylation should also be investigated.

Effect of crystallinity on the infrared absorption of cellulose. In studies on infrared absorption under this project, it was found that sharpness of the absorption bands appears to be related to the degree of cyrstallinity of the carbohydrates. Preparation and study of a series of celluloses differing in crystallinity would permit evaluation of the members of the series with respect to infrared absorption, x-ray diffraction, and crystallinity by acid hydrolysis, as well as an investigation of the correlations between these methods of measuring this valuable property of fibers.

The practical significance of studies on the crystallinity of cellulose. There are four main factors involved in the crystallinity of cotton cellulose: (1) the nature of the crystal structure, (2) the ratio of crystalline to noncrystalline material in the cotton cellulose, (3) the size of the crystals, and (4) the orientation of the crystals. Crystallinity studies have proceeded far enough to show that some at least of these factors have a marked influence on certain of the important physical properties of cotton. For example, decreased crystallinity and higher content of noncrystalline cellulose result in increased stretch and elastic recovery, increased absorptive capacity for moisture, and increased chemical reactivity of the cotton fiber; furthermore, improved orientation of the crystals results in an increase of the fiber strength. These facts have been established on the basis of the small amount of data already accumulated. There is need for extended studies in this field to perfect the methods for determining the crystallinity of cotton cellulose and to develop satisfactory techniques for varying the crystallinity to meet the requirements of specific end uses.

DEVELOPMENT OF NEW AND IMPROVED PRODUCTS FROM COTTON FIBER THROUGH PROCESSING AND CHEMICAL TREATMENTS

(BAIC - RM:a-104 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

To promote utilization of cotton by increasing the utility and attractiveness of cotton products through chemical treatments and mechanical processing. The current work is particularly concerned with (1) the development of new and improved mechanical and chemical processing methods and chemical treatments in order to produce cotton products that more adequately meet consumer requirements and competition from other products, (2) the development of new and improved cotton processing equipment and methods for improving quality and lowering costs, and (3) the development of new testing equipment and techniques for evaluating product quality.

B. Currently Active Line Projects

RM:a-104-1 - Effect of twist on the efficiency of weaving and quality of woven fabrics. To improve loom operating efficiency and fabric quality and to reduce manufacturing cost by determining the twist for warp yarns that will result in a minimum amount of end breakage and yarn abrasion during weaving.

RM:a-104-2 - Fabrics of improved quality made from blends of cotton with other fibers. To survey and appraise previous experiments to blend cotton with other fibers, and to determine where blending cotton with other fibers might be advantageous in increasing the use of cotton.

RM:a-104-3 - Development of cotton fabrics and garments of good warmth-imparting quality. To explore the possibilities of increasing the use of cotton in outer-garments, through the development of cotton fabrics and garments having improved, permanent warmth-imparting quality.

RM:a-104-4 - Development of improved plastic laminates with cotton as the filler. To explore the possibility of increasing the use of cotton in the important plastic-manufacturing industry by developing formulation and processing methods that will demonstrate the superior properties of laminate structures containing cotton, as compared to those made with competitive fibrous materials.

RM:a-104-5 - Improvement of the resistance of cotton bagging fabrics to penetration by insects and rodents. To devise practical insect- and rodent-repellent finishes or treatments for cotton flour and feed bags so as to maintain the position of cotton in this important field against competition of multi-walled paper bags. The research is carried on in cooperation with the Bureau of Entomology and Plant Quarantine.

RM:a-104-6 - Development of swelling-type, water-resistant fabrics. To produce cotton fabrics that will resist the penetration of water by virtue of their inherent swelling and closing properties when wetted. Since water-repellent finishes decrease in effectiveness with time and service, it is desirable to have cotton fabrics that possess a reserve water-resistance capacity independent of finish.

RM:a-104-7(C) - Determination of the factors which influence the draping properties of cotton fabrics. To establish quantitative relationships between cotton fiber properties, yarn and fabric structure, and the draping properties of cotton fabrics, which will serve as a basis for the design and development of cotton fabrics having improved draping properties. This project is being conducted under contract by a private textile research organization.

RM:a-104-8 - Development of new equipment for cleaning mechanically picked cotton at textile mills. To develop improved methods and machines for cleaning lint cotton at the textile mill, with emphasis on apparatus designed especially for processing cottons of high foreign-matter content produced by mechanical harvesting methods.

RM:a-104-9(C) - The adaptation of cotton yarns for tricot knitting machines. To investigate methods for making cotton yarn more suitable for high-speed, tricot knitting in order to lower processing costs and make cotton more competitive with synthetic fibers in tricot-knitted fabrics. This project is being conducted under contract by a State educational institution.

RM:a-104-10(C) - Improved control of neps (knots) in the manufacture of cotton textiles. To investigate causes of nep formation and to develop means for reducing the number of neps in order to make cotton fabrics more attractive and more competitive with synthetic fabrics. This project is being conducted under contract by a State educational institution.

RM:a-104-11(C) - Improvement of cotton textiles to soiling. To determine the factors that influence soiling and soil retention by cotton textiles, and to investigate treatments or finishes that will both decrease their readiness to become soiled and at the same time facilitate the removal of soil in laundry operations. This project is being conducted under contract by a textile research institution.

RM:a-104-12(C) - Improvement of cotton warp yarns for carpets. To improve cotton yarns for use as carpet warps by increasing their uniformity and strength-bulk ratio. This project is being conducted under contract by a State textile school.

RM:a-104-13(C) - Improvement of the luster of cotton textiles. To carry out a fundamental study of the properties of cotton fibers that influence luster; to devise satisfactory methods for measuring or characterizing luster in cotton materials; to determine if varying degrees of luster exist in different varieties of cottons; and to develop improved physical or chemical processing methods for increasing luster. This project is being conducted under contract by a private research organization.

RM:a-104-14 - New types of cotton textile products made by etherification. To develop processes for reacting organic compounds with cotton to produce compounds of cellulose and oxygen having valuable properties, such as the ability to absorb acid or basic groups of compounds dissolved in water.

RM:a-104-15 - Measuring heat transmission of fabrics. To develop apparatus and techniques for measuring the heat transmission of cotton fabrics in order to evaluate their insulating or warmth-imparting value.

C. History and Evolution of this Work

Limited research to find new uses and extend present uses for American cotton was begun in the Bureau of Agricultural Economics in about 1927, but it was about 1940, after the establishment of the Regional Research Laboratories, that cotton-utilization research was placed in the Bureau of Agricultural Chemistry and Engineering and the program greatly expanded. The scale of this effort was later judged to be too small by a special Subcommittee on Cotton of the House of Representatives, which held hearings on the research needs of cotton. As a result, this project on development of new and improved cotton products through processing and chemical treatment was approved in 1948, and funds were allotted from appropriations authorized by the Research and Marketing Act of 1946. Only line projects recommended by the Cotton Technical Subcommittee and approved by the Cotton Advisory Committee have been initiated. Six of the 15 line projects undertaken so far are being conducted under contract.

D. Funds -- Annual Expenditures

During the 3 fiscal years this project has been active, namely 1948, 1949, and 1950, the approximate annual expenditures have been $~~115,990~~ 302,000, ~~$94,600~~ 179,000, and ~~$156,790~~ 229,000, respectively.

E. Examples of Outstanding Accomplishments

Development of swelling-type, water-resistant fabrics. Closely woven fabrics have been made from cotton containing a relatively large amount of thin-walled, or so-called immature, fibers. Such fabrics have been shown to possess better swelling and closing properties when wetted than similar fabrics made from mature cotton. A striking degree of resistance to water penetration is exhibited by the former, and this property can be enhanced still further by utilizing a new loom attachment that permits weaving an increased number of filling threads per inch in the fabric structure.

New cotton fabric for chemical-purification purposes. Sulfoethyl cotton, a new type of chemically modified cotton fabric, made with standard finishing equipment, is a material that has strong acidic properties and absorbs bases from solution. It may be used for certain industrial chemical processes, such as water-softening.

Making cotton textiles resistant to soiling. A method of treating cotton materials with carboxymethyl cellulose, a commercially available substance, has been developed. Cotton garments and household articles subjected to this treatment are more resistant to soiling and much easier to clean in ordinary laundering. The substance is applied like starch, and, since the treatment is simple and effective, it will probably be widely used both in commercial laundries and in the home. Since cotton fabrics soil more easily than those made of some competitive fibers, the economic importance of a practical, soil-preventing treatment for cotton is readily apparent. Moreover, making the need for laundering less frequent will extend the life of cotton wash goods.

Improving the resistance of cotton bagging fabrics to penetration by insects. Treating cotton flour bags with a low concentration of pyrethrins (the biologically-active constituents of insect powder) was found to be effective in preventing penetration by insects, even when the filled bags were stored for many months under conditions that assured heavy infestation of untreated bags. The protective chemical can be applied to the warp yarns with the sizing material prior to weaving, or it can be applied in the finishing processes in the case of back-filled bag fabrics. The chemical costs about one cent per square yard treated, and its application, in the operations mentioned, entails no additional processing cost. Since the pyrethrins gradually deteriorate through the action of light, various substances are now being investigated as supplements to prevent this deterioration and prolong the effectiveness of the treatment.

Improved control of neps (knots) in the manufacture of cotton textiles. Significant progress has been made in developing apparatus and techniques for investigating nep formation and methods for reducing it. Noteworthy developments are: (1) A template, for counting neps in the card web, that is convenient and gives dependable results; (2) a system of dial gauges that makes it possible to quickly change the flat-settings without removing the flats, thereby materially speeding up the study of nep formation as affected by flat-settings; (3) a conveyor, for supporting a full-width card web, that makes possible the removal of a full-width web for convenient inspection and sampling; (4) a standardized photographic method for printing card-web shadowgraphs so that the neps can be made to stand out for evaluation; and (5) a chart that permits quick conversion of number of neps per unit area to number of neps per unit weight -- for example, from neps per 100 square inches to neps per gram.

F. Some Additional Work Needed

Treatments to improve soil resistance of cotton textiles requires further investigation of the most promising method so far developed -- treatment of washable articles with carboxymethyl cellulose -- from the standpoint of its practical application in commercial laundries and in household use. This treatment has shown excellent experimental results, and there should be additional development to the point of popular acceptance.

Dry cleaning methods for cotton fabrics should be investigaged to develop effective dry cleaning methods for cotton garments and household furnishings. While cotton is exceptionally well suited to ordinary laundering, such wet processing involves subsequent pressing, as well as frequent problems of shrinkage, that could often be avoided if a satisfactory dry cleaning treatment could be employed.

Influence of "drag" (frictional properties) upon the processing behavior of cotton fibers. Research conducted to date has shown that the "drag" of cotton fibers, or the resistance of cotton fibers in the aggregate to slipping over each other, differs appreciably in different types of cotton. It is believed that this characteristic of cotton should be correlated with certain important elements of "spinning value", such as twist required for optimum yarn strength, maximum permissible drafting ratio, and number of ends down during the drafting and spinning processes. A thorough, systematic study should be made to determine whether or not such relationships do exist between "drag" and spinning value.

Development of new textile spinning equipment. Present methods of spinning yarns from cotton fibers have the disadvantages of low production rate, limited package size, and non-uniformity of product. With approximately 95 percent of the cotton crop going into yarns, the development of equipment for rapidly spinning yarns of high quality would be a major contribution to the entire cotton industry.

Development of fabrics of improved quality from blends of cotton with other fibers. Cotton has suffered substantial losses in women's, misses', and juniors' apparel. In almost every instance, the loss could be attributed to cotton's lack of sufficient luster, good drape, crush and wrinkle resistance, or resistance to clinging. The most desirable thing, from the standpoint of a greater use of cotton, would be to impart these properties through treatments that modify all-cotton fabrics. However, since research to date has not produced acceptable chemical or mechanical finishes for giving cotton these properties, research studies aimed at acquiring greater luster and good drape through blending cottons with other fibers is needed. Research is also needed on blends of cotton with other fibers to develop more acceptable fabrics for (1) men's and youths' summer suits, (2) enlisted men's summer uniforms, (3) linings for suits and overcoats, and (4) men's and youths' dress and semi-dress hosiery.

Spinning drafts for maximum uniformity of coarse, medium, and fine yarn numbers. Best drafts for spinning different yarn numbers on long-draft systems have not been clearly defined. A critical study of the influence of different drafts on yarn uniformity is needed to determine the drafts that give optimum yarn uniformity for coarse, medium, and fine yarns. These data would furnish cotton spinners with valuable information for improving yarn quality and machine performance and would assist in making cotton products more competitive with other textile products.

Effect of doubling on uniformity. Feeding multiple strands of sliver to a drawing frame is employed in textile mills on the assumption that the heavy and light sections of the strands will offset one another and that increased uniformity will result. However, the fact that drawing sliver is generally more uneven than card sliver, on an inch-to-inch basis, indicates the need for critical studies to determine the effects of certain factors, such as (1) number of doublings, (2) ratio of doublings to draft, and (3) use of one, two, or three processes of drawing, on the uniformity of cotton yarns and production rates.

Effect of drafting roll spacing on uniformity and production. In order to prevent cotton fibers from being caught and broken by adjacent sets of drafting rolls, it is necessary to space them so that the distance from bite to bite slightly exceeds the length of the fiber to be processed. This spacing is critical, since some of the longer fibers will be broken if the rolls are set too close; however, if the drafting rolls are set too far apart, drafting will be uneven and non-uniformity will result. Roll settings are largely determined by trial-and-error methods, and differences in practice exist in different mills. Critical studies are needed to guide production practice in the spacings of the different sets of rolls to obtain optimum uniformity and fewest machine stops.

Research on production of new fibers from cotton by chemical treatment should be expanded, since recent developments have shown that new and valuable properties can be imparted to cotton products by such means. Numerous chemicals that combine with cotton cellulose should be investigated, and the new products thus formed should be evaluated for useful textile properties.

The dyeing properties of new chemically modified cottons should be fully determined from the standpoint of commercial processing, since these properties are usually different from those of unmodified cotton and can be properly characterized only through complete investigation.

SERVICEABILITY STUDIES OF CLOTHING AND HOUSEHOLD FABRICS COMPOSED OF COTTON AND OTHER FIBERS
(BHNHE RM:a-9 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

To compare, in the laboratory and under conditions of actual use, the wearing qualities of woven clothing and household fabrics composed entirely of cotton and of combinations of cotton and other fibers. Current work is concerned with studying fabrics made according to specifications from fibers of known history. Results provide the factual basis needed to develop consumer standards for staple fabrics, to guide manufacturers in the production and informative labeling of goods, and to help consumers in their buying.

B. Currently Active Line Projects

RM:a-9-1 - Serviceability of utility percales made of different varieties of cotton. To determine by wear tests of work dresses the relative serviceability of three qualities of percale composed entirely of cotton.

RM:a-9-2 - Relative usefulness to consumers of cotton and manufactured fibers in household and clothing fabrics. To determine the serviceability of bed sheeting composed entirely of cotton, entirely of viscose staple rayon, and of various combinations of the two.

C. History and Evolution of This Work

Exploratory studies of the wearing quality of fabrics of known composition and construction, initiated in the Department in 1929, were concerned with the relative usefulness of medium-weight muslin bed sheeting made from three grades of American Upland cotton, and heavy-weight muslin sheetings made from two varieties of cotton grown under different climatic conditions. In addition, the serviceability of sheets bought on retail markets was studied. Later, because of the growing competition of rayon with cotton, a study of the comparative wearing quality of two types of knit garments, each made entirely of cotton or entirely of viscose filament rayon, was undertaken and completed in the late 1930's.

In 1948, in cooperation with State research groups, the evaluation of clothing and household fabrics for their resistance to wear was undertaken on an enlarged scale with Research and Marketing Act funds. Methods and fundamental information developed in previous studies have expedited these further investigations of fiber and fabric performance.

D. Funds--Annual Expenditures

Annual expenditures of regular funds from 1929 to the late 1930's were from $3,000 to $8,000. For the years 1948, 1949, and 1950, the annual expenditures of RMA funds were $50,000, $70,000 and $70,000, respectively.

E. Examples of Outstanding Accomplishments

Comparative serviceability of medium- and heavy-weight bed sheets. These studies yielded the first information ever obtained concerning the service life of bed sheets made from fibers and fabrics of known composition and construction. Medium-weight muslin sheets made from Good Middling and Middling cotton of 1- and 1-1/32 inch staple length, respectively, were found to wear, on the average, 16 percent longer than similar sheets made from Strict Good Ordinary cotton of 1-inch staple. Heavy-weight muslin sheets made from 15/16 to 1-inch Middling cottons withstood, on the average, between 276 and 281 use-periods (one period of wear followed by laundering); medium-weight muslin sheets made from American Upland cotton of the same grade and staple length withstood an average of 239 use-periods.

Evaluation of sheetings composed entirely of cotton, entirely of staple viscose rayon, and a mixture of the two fibers. Shortly after the close of World War II, sheets made of part cotton and part rayon began to appear on the retail market. In a laboratory comparison of sheetings identical in yarn and fabric construction, those composed entirely of cotton were found to be better in breaking strength, resistance to abrasion (wear from rubbing), resistance to damage in laundering, and in dimensional stability than those composed wholly or in part of viscose staple rayon. All-cotton sheets shrank approximately 7-1/2 inches (7 percent) in length; the all-rayon and the part-rayon, about 19 and 13 inches (18 and 12 percent), respectively. This study, still in progress, is providing the first factual information ever obtained regarding the serviceability of cotton sheetings as compared to other fabrics identical in manufacture except for fiber composition.

F. Some Additional Work Needed

Further studies of the effect of yarn and fabric construction upon the wearing quality and other characteristics of fabrics should be initiated in order to ascertain the type, grade, and staple of cotton, as well as the kind and size of yarn and the fabric weave most suitable for specific household and clothing purposes. Other studies are needed to learn the effect of modifications in yarn and fabric structure upon the strength of the fabric, its resistance to shrinking and stretching, its luster, and its resistance to soiling and wrinkling. This information is especially needed for materials subjected to hard wear or to the deteriorating effects of heat, light, and weathering.

Effectiveness of finishes used to improve the natural characteristics of cotton should be determined by actual use tests. Finishes to impart desirable properties to cotton not inherent in the fiber are on the market and being developed by many groups. The permanence and the effect of such treatments upon the durability and other characteristics of the fabrics await investigation.

Development of standards of quality for cotton clothing and household fabrics is needed to aid homemakers in selecting fabrics best suited to a particular purpose. The need for designations of quality expressed in simple terms on labels is emphasized by the growing practice of retailing cotton articles in packaged form. Specifications should be developed for different grades of staple fabrics in terms of fiber content, yarn and fabric construction, resistance to shrinking and stretching, and the fastness of dyes to light and washing. Should production for civilian needs be restricted during an emergency, such standards would provide the basis for developing specifications for utility fabrics similar to those made in England under government regulation during the last war.

UTILIZATION INVESTIGATIONS ON COTTONSEED *

(BAIC - RRL-2-3, Subcommodity Project 2 - Federal-State - Regular Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To develop new, scientific, chemical, and technical uses and new and extended markets and outlets for cottonseed and cottonseed products. The current work is particularly concerned with both applied and fundamental research on the storage and processing of cottonseed, the keeping quality of edible types of cottonseed oil and its products, the modification of cottonseed oil for industrial applications, the methods of processing cottonseed oil for edible products, and the utilization of cottonseed meal and its products.

B. Currently Active Line Projects

RESEARCH PROJECT RRL-2-(3)-0-1 - FLAVOR AND ODOR STABILITY OF COTTONSEED OIL AND DERIVED PRODUCTS.

RRL-2-(3)-0-1-1 - Improvement in the flavor, odor, keeping quality, and other properties of cottonseed oil. To determine the cause of, and the products responsible for, the development of rancidity and other forms of deterioration in cottonseed oil and its derived products, and to develop methods of increasing the flavor and odor stability of this oil and edible products (salad and cooking oils, shortenings, margarines, etc.) made from it and of the consumer goods (potato chips, fried nuts, doughnuts, prepared dough mixes, etc.) prepared therefrom.

RESEARCH PROJECT RRL-2-(3)-0-2 - PROCESSING AND UTILIZATION INVESTIGATIONS OF COTTONSEED OIL.

RRL-2-(3)-0-2-1 - Modification of cottonseed oil to improve its usefulness in industrial applications. To produce from cottonseed oil, through the application of existing or new methods of processing, new or improved fat products, including "tailor-made" fats capable of serving as replacements for imported fats and oils (cocoa butter, palm oil, et al.) and to improve existing methods or devise new methods of processing to improve the yield and quality of finished products and to reduce their cost.

RRL-2-(3)-0-2-2 - Investigation of the physical behavior and characteristics of cottonseed oil and its derivatives. To measure quantitatively those physical properties (expansion, contraction,

---

* A Commodity Project of one of the Regional Research Laboratories administered by the Bureau of Agricultural and Industrial Chemistry. Under Section B of this report, currently active Line Projects are grouped under their parent Research Projects, which correspond approximately in scope to the regular Work Projects of other Bureaus of the Department. Likewise, under Sections D and E, Research Projects are used as the basis for reporting expenditures in 1950, and outstanding accomplishments.

and changes in crystal structure) of cottonseed oil and its derivatives that are important and useful in processing and utilizing these products, and to apply this knowledge in separating cottonseed oil into components having more diversified uses than the original oil.

RESEARCH PROJECT RRL-2-(3)-O-3 - CHEMISTRY AND UTILIZATION INVESTIGATIONS ON COTTONSEED OIL AND BYPRODUCTS.

RRL-2-(3)-O-3-1 - Composition of cottonseed oil and byproducts. To determine the types and amounts of fatty acids which are produced in cottonseed oil by selective hydrogenation (hardening) to produce fats (shortening, margarine oil, confectioner's fats, etc.) of different degrees of hardness.

RRL-2-(3)-O-3-2 - Preparation of derivatives from the fatty acid and glyceride components of cottonseed oil. To prepare pure esters, mono-, di-, and tri-glycerides, and other compounds from cottonseed oil fatty acids and to evaluate them with respect to such properties and applications as are of use in the development of new market outlets for this oil.

RRL-2-(3)-O-3-5 - Investigations on the pigments of cottonseed and its derived products. To isolate, identify, and determine the properties of pigments of cottonseed and its derived products and to apply this knowledge to solving the various color problems affecting the production and use of cottonseed oil and products manufactured from this oil.

RESEARCH PROJECT RRL-2-(3)-PC-1 - CHEMICAL, TECHNOLOGICAL, AND UTILIZATION INVESTIGATIONS ON MEALS AND PROTEINS OF COTTONSEED.

RRL-2-(3)-PC-1-2 - Isolation and characterization of the proteins and other non-oil constituents of cottonseed. To develop industrial uses and applications for cottonseed meals, flours, and protein preparations, either *per se* or after fractionation and modification of these products, and by isolation of new proteins and other non-oil materials from cottonseed.

RRL-2-(3)-PC-1-3 - Development and utilization of cottonseed meals and proteins for tire cord dips. To develop adhesives from cottonseed meals and proteins for use in tire cord dips for bonding the cord to the rubber of the tire carcass.

RRL-2-(3)-PC-1-4 - Development of cottonseed meal and protein plywood glues. To develop cottonseed meal and protein plywood glues having increased strength and water resistance by chemical modification of the cottonseed meal and protein and by formulation of glues containing cottonseed meal and protein.

RESEARCH PROJECT RRL-2-(3)-PC-2 - INVESTIGATION AND CONTROL OF BIOLOGICAL FACTORS CAUSING HEATING AND DETERIORATION OF COTTONSEED.

RRL-2-(3)-PC-2-1 - Application and control of the enzymes and enzyme systems of cottonseed and its derived products. To develop methods of control of enzyme activity in cottonseed to prevent or retard the deterioration of the seed during harvesting, handling, storage, and processing. This work is conducted in cooperation with a private meat packing company and a cotton processing company, for investigations on commercial storage, and with the Mississippi Agricultural Experiment Station for investigation on deterioration of planting seed. Cooperation with National Cottonseed Products Association has involved the support of a fellowship to aid this work.

RESEARCH PROJECT RRL-2-(3)-E-3 - COTTONSEED PRODUCTS PROCESSING INVESTIGATIONS.

RRL-2-(3)-E-3-1 - Pilot-plant cottonseed preparation. To determine on a pilot-plant scale, the best procedures and processes for cleaning, delintering, hulling, rolling, cracking, flaking, and otherwise preparing cottonseed prior to extraction of the oil by hydraulic pressing, screw pressing, or by means of solvents.

RRL-2-(3)-E-3-2 - Pilot-plant solvent extraction of cottonseed. To determine on pilot-plant scale the optimum conditions for solvent extracting cottonseed to obtain highest yield and best quality of oil and meal.

RRL-2-(3)-E-3-3 - Pilot-plant solvent crystallization of cottonseed oil and derived products. To develop on a pilot-plant scale, a practical process for separating cottonseed oil into two or more portions having greater utility or value than the original oil by partial freezing and filtering off one or more solid portions from solutions of the original oil in organic solvents.

RRL-2-(3)-E-3-4 - Pilot-plant processing of cottonseed meal for production of protein. To develop on a pilot-plant scale, a practical process for separating protein from cottonseed meal, and to supply quantities of protein, extracted meal, and whey for further research and commercial evaluation.

RRL-2-(3)-E-3-5 - Pilot-plant processing of cottonseed oil and derived products. To develop on a pilot-plant scale, improved methods of refining, bleaching, hydrogenating, deodorizing, and fat-splitting, and other methods of processing cottonseed oil to produce special, more useful, or more valuable products.

RESEARCH PROJECT RRL-2-(3)-E-5 - ENGINEERING SERVICES ESSENTIAL TO THE RESEARCH PROGRAM ON COTTONSEED.

RRL-2-(3)-E-5-1 - General engineering services. To provide general engineering services in support of other lines of work on cottonseed, including the design, purchase, installation, and maintenance of equipment used in such work; to maintain and supply up-to-date information on processing equipment; and to supply consulting engineering advice regarding equipment, processing methods, electrical and structural codes, etc.

RESEARCH PROJECT RRL-2-(3)-A-4 - ANALYTICAL, PHYSICAL CHEMICAL, AND PHYSICAL INVESTIGATIONS OF COTTONSEED.

RRL-2-(3)-A-4-1 - Analytical, physical-chemical, and physical investigations of cottonseed and cottonseed byproducts. To assist in the research described in other line projects on cottonseed by: (a) providing miscellaneous analytical services, physical-chemical measurements, research services, and specialized physical measurement services; (b) improving existing and developing new evaluation methods; and (c) obtaining data on chemical composition and physical properties.

RRL-2-(3)-A-4-10 - Solubility of cottonseed oil in organic solvents. To obtain fundamental physical-chemical data on the solubility behavior of cottonseed oil in various solvents at reduced temperatures.

C. History and Evolution of This Work

Research on cottonseed and cottonseed products and byproducts was initiated about 1920 in the Bureau of Chemistry on a very limited scale. Between 1920 and 1940 various samples of crude cottonseed oil were examined and reports issued on the nature and amount of some of the constituents of these oils.

Research was conducted on the problem of flavor and odor stability of cottonseed oil, for a short time through the medium of a fellowship of the Mayonnaise Manufacturers Association (1931) and later through the medium of a fellowship of the National Cottonseed Products Association (1937-46). The early work was concerned principally with the development of methods of detecting and quantitatively evaluating rancidity and to a lesser extent with the fundamental chemical changes occurring in cottonseed oil and the products formed during rancidification. During this early work (1931) on flavor and odor stability, there was developed a method which proved to be of inestimable value to the fat and oil industry because it made possible the determination and prediction of the keeping quality of fats and oils. This method is daily applied throughout the industry for evaluating the stability of fats and oils.

Compositional and nutritional studies on cottonseed meal and protein were begun about 1917 and continued until 1930 or later during which interval the principal protein components of cottonseed were isolated, characterized, and their amino acid compositions determined. During these studies the nutritive value of the mixed and isolated proteins were investigated. These and related investigations have formed the basis of all further research on the utilization of cottonseed meal and protein. The first work on the pigments of cottonseed was carried out by a research fellow of the National Cottonseed Products Association between 1926 and 1929. These investigations were directed toward the chemistry and physiology of gossypol, the only well known pigment of cottonseed at that time.

Prior to the establishment of the Regional Research Laboratories no work was done on the modification of cottonseed oil to produce "tailor-made" fats and fat products, or on crude oil mill and refinery processes to improve the quality of previously known products, or on the development of uses for byproducts of these processes. During the 1930's many farm commodities, including fats, oils, and oilseeds were produced in surplus. With a view to broadening the outlets and expanding utilization, Congress in 1938 authorized the Bureau to conduct crop-use research for the major commodities of each region. The resultant program of research has included investigations on the storage and processing of cottonseed, on food and industrial uses of cottonseed oil, and on the industrial utilization of cottonseed meal and its constituents, principally the protein.

Attention has been given in the enlarged program, starting in 1941 with the completion of the Regional Laboratories, to the development of research of a fundamental nature on the chemical and physical properties and reactions to support or provide a basis for applied utilization research, especially on cottonseed oil.

D. Funds - Annual Expenditures

Prior to 1941 the expenditure of funds for research on cottonseed and cottonseed oil were relatively small. Generally no more than two or three chemists were engaged in research on all of the domestic oilseed crops. It is estimated that $10,000 a year was spent on research on all fats and oils. A very considerable amount of the then current research was carried out by the research fellows whose salaries were paid by various sponsoring trade associations. Between 1941 and 1949, annual expenditures under the cottonseed utilization subproject ranged from $75,000 in 1941 to $330,000 in 1949, averaging about $250,000. The expenditure in 1950 was $316,000 which was apportioned among the various Research Projects as follows: O-1, $27,500; O-2, $41,000; O-3, $22,500; PC-1, $17,500; PC-2, $17,500; A-4, $59,000; E-3, $118,000; E-5, $13,000.

E. Examples of Outstanding Accomplishments

RESEARCH PROJECT RRL-2-(3)-O-1.

Improvement in the flavor, odor, and keeping quality of cottonseed oil. The loss resulting from the deterioration or rancidification of fats and oils in storage and in use both per se and in the form of finished goods containing these substances has been estimated to amount to many hundreds of thousands of dollars annually. Investigations on the stability of cottonseed oil have led to the development of reliable and sensitive methods of predicting the shelf life of processed fats and oils, and of detecting the onset and degree of rancidification in these products. The role of natural antioxidants in inhibiting rancidity in cottonseed oil and the effect of added inhibitors (antioxidants) has been established. A new antioxidant, norconidendrin, has been developed from a waste product of the pulping of wood. It is highly effective in preserving fats and oils and for other uses and is being produced commercially for a variety of uses where antioxidant protection is required. Fundamental investigations have resulted in the elucidation of the mechanism of rancidification of cottonseed oil and in the isolation and identification of several of the products that are responsible for the rancid odor and flavor of rancid cottonseed oil. This work is recognized as an outstanding contribution to the solution of the problem of rancidity in fats and oils and has found application in industry in the control and production of fatty products of superior stability.

RESEARCH PROJECT RRL-2-(3)-O-2.

Development of new fat products. Semi-pilot plant, batch equipment was designed and a process devised whereby refined cottonseed oil can be converted into a salad oil in 2 to 4 hours compared to the present conventional process which requires five to six days. The experimental results and data were applied in designing and fabricating a continuous commercial size unit for carrying out the process.

The process has not been adopted commercially because it necessitates scrapping present winterization plants and installing new and relatively expensive equipment. The most effective use of this process will be in connection with continuous solvent refining of cottonseed oil which is still in the developmental stage by industry.

Substitute for palm oil for use in the tin plate industry. Palm oil has always been considered an absolute necessity in the production of tin and terne plate and for the cold reduction of sheet steel. During World War II when supplies of palm oil from Africa and the South Pacific were cut off, a suitable substitute was developed by the selective hydrogenation of cottonseed oil to a semifluid state. The hydrogenated oil proved to have the desired fluxing properties and to have longer life in the tin bath than did palm oil, as determined by laboratory and plant tests by several producers of tin and terne plate. Diversion of cottonseed oil from food to industrial channels was prohibited under the system of allocations in force during the War, thus preventing the continued use of the product on a commercial scale to replace palm oil.

Plastic fats. A large number of investigations on plastic fats involving the development of new instruments and methods for the measurement of the special properties of these important food products (shortening, margarines, enrobing and confectioners' fats, etc.) have been completed and the results applied industrially to obtain better control of the unique properties (ratio of solid to liquid fat, crystal structure of the solid portion, hardness, plasticity, emulsifying properties, etc.) of plastic fats.

RESEARCH PROJECT RRL-2-(3)-0-3.

Composition of cottonseed oil and byproducts. The fatty acid composition of cottonseed oil before and after hydrogenation (hardening) to various consistencies (plasticities) has been thoroughly investigated and the composition correlated with plastic values and the keeping quality (stability) of the hardened oils. The type and amounts of natural antioxidant (vitamin E) in cottonseed oil at various stages of processing into finished fats have been established.

Preparation of synthetic derivatives of the fatty acid and glyceride components of cottonseed oil. A considerable variety of chemical derivatives (esters, acid chlorides, hydrazides, maleic anhydride adducts, hydroperoxides, and long chain keto esters) of cottonseed oil fatty acids have been prepared and their properties investigated. Because of their value as chemical intermediates, the acid chlorides of the fatty acids present in cottonseed oil were prepared and their properties and reactivities determined. The hydrazides of cottonseed oil fatty acids have been prepared and their value as reagents for separating and identifying individual fatty acids in mixtures of naturally occurring acids has been established.

Investigations on the pigments of cottonseed and derived products. Since 1940 the cottonseed pigments and the associated color problems of the derived oil and meal have been the object of intensive research. In addition to the previously known pigment (gossypol), several heretofore unknown pigments (gossypurpurin, gossyfulvin, and gossycaerulin) have been isolated, named, and characterized. Methods of analysis for these pigments were developed and applied to an investigation of their occurrence and changes in the seed as a function of variety and conditions of storage, and in the control of the color of crude oil. Intact pigment glands were isolated for the first time and a method developed for producing these glands in quantity for use in investigating the nature of the glands, the types and quantities of pigments contained therein, and in studies of their physiological action. The culmination of this work was a patented process for the production of relatively light-colored, crude cottonseed oil; relatively pigment-free meal; and pigment glands as a raw material for the production of gossypol. The process is being evaluated with respect to its industrial feasibility under Research Project RM:a-103-2.

RESEARCH PROJECT RRL-2-(3)-PC-1.

Cottonseed protein fiber. No use has heretofore been made of cottonseed protein in the production of artificial protein fibers because no means has been known for overcoming the inherent poor solubility and excessive color of this protein as it is normally produced. Within the last two years a process has been developed on a laboratory scale, for the production of an artificial fiber from the protein contained in cottonseed meal. A patent covering the process has been granted.

Cottonseed meal plywood glue. A glue product having the viscosity, consistency, and spreading characteristics necessary for good gluing operations in plywood manufacture has been prepared from solvent-extracted cottonseed meal. This glue preparation may be utilized for the manufacture of plywood by standard hot-pressing procedures. In laboratory tests in which each glue mix and glue line was prepared as recommended to give maximum shear strengths, it compared favorably with commercial casein glues. It proved to be better than casein glue when compared on a wet-test basis. Arrangements are being made with a commercial producer of cottonseed meal and a plywood manufacturer to make industrial scale tests of this product.

RESEARCH PROJECT RRL-2-(3)-PC-2.

Seed deterioration. Laboratory and field investigations have made available data that show the effects of such factors as temperature, moisture content, and maturity on the rate of seed deterioration. Over 300 chemicals have been laboratory-tested as agents for preventing deterioration of stored cottonseed. Approximately one-sixth of the chemicals tested were found to be effective when used in amounts of less than 0.4 percent on the dry weight of the seed treated. Commercial manufacturers of organic chemicals have used the method of testing developed in the course of this work to evaluate products that they manufacture as potential inhibitors of deterioration in stored seeds. In tests conducted in commercial cottonseed oil mills, a combination of chemical treatment and forced-air ventilation inhibited heating of moist cottonseed for 132 days and retarded the formation of free fatty acids in the oil for 52 days. The first, or screening phase, of the problem of combating deterioration in stored cottonseed has been accomplished. Evaluation in commercial mills of the methods developed under this project has indicated the nature of future research which is required to perfect the process. The National Cottonseed Products Association is supporting this research by means of a fellowship.

Preservation of planting seed. Field tests of cottonseed treated with low concentrations of a mixture of chemicals have shown that seed viability is maintained, fewer deaths of seed occur in the hills two weeks after planting, and the lint from the first generation of the seed is unaffected by the treatment. The results have attracted the attention of commercial producers of planting seed and they have indicated their willingness to cooperate in continuing this work by applying under commercial storage conditions the tests and methods developed in the course of this investigation. This research has been facilitated by cooperation with the Mississippi Agricultural Experiment Station.

Equilibrium moisture content data guide cottonseed storage operations. Data on the moisture content of cottonseed that is in equilibrium with air over the range of 11 to 93 percent relative humidity at 77° F. were developed and made available to the cottonseed industry. This information has been used by commercial handlers of cottonseed and research workers to guide them in determining when to take advantage of favorable atmospheric conditions to dry seed by forced-air ventilation. It has also permitted cottonseed oil mills to estimate the moisture content of large piles of seed by using these data in conjunction with local weather reports.

RESEARCH PROJECT RRL-2-(3)-E-3.

Improvement in the preparation of cottonseed for oil extraction. It was demonstrated that when the moisture content of cottonseed is adjusted by proper conditioning (9 to 10 percent in the kernels or 11 to 12 percent in the whole seed), more whole kernels and fewer broken ones and fine particles are produced during hulling. Furthermore, the hulls are readily removed in the form of large particles, thereby improving the efficiency of separating the hulls and kernels by screening and air cleaning and lessening the loss of oil with the separated hulls.

In the case of solvent extraction of cottonseed the production of higher yields of whole kernels through proper control of the moisture content greatly improves the flaking operations. Proper control of the moisture content also improves the stability of the flakes, reduces the amount of fines produced during extraction, improves the flow of solvent through the flakes, and the extractability of the oil in the flaked material. Because of the improved control of moisture and separation operations the color of the oil and meal are also improved. These improved methods of preparation are applicable to hydraulic and screw pressing as well as in the solvent process. The more uniform moisture content of the kernels improves the cooking operations prior to hydraulic and screw pressing and results in improved color of the expressed crude oil.

These significant advances in the preparation and flaking of cottonseed kernels, and their effects on the quality of the oil and meal produced, as well as other technical data and information from related investigations have been brought to the attention of, and discussed in detail with superintendents and managers of cooperative oil mills in a series of working conferences which have contributed materially to improving operations in these mills.

Improved color of solvent-extracted cottonseed oil. In the final stages of evaporating the solvent from cottonseed oil-solvent mixtures the temperature of the mixture rises appreciably. Furthermore, at high concentrations of oil in the mixture, the boiling points of the solvent do not conform to the physical laws applicable to the evaporation of pure solvents. In the case of cottonseed oil-solvent mixtures obtained in solvent extracting flaked cottonseed high temperatures also result in increased formation of color in the oil. An investigation was made to determine the boiling points of concentrated mixtures of cottonseed oil and solvent (commercial hexane) and on the color of the oil as affected by the boiling point of the mixture. The results of these investigations have provided data which have been applied to the proper design of evaporator equipment and to the commercial recovery of crude cottonseed with minimum alteration of the natural color bodies.

Continuous solvent extraction of cottonseed on pilot-plant scale. A pilot plant has been installed for the continuous solvent extraction of flaked cottonseed at the rate of 150 pounds per hour. The plant has been operated to produce prime quality oil and meal. The relatively small amount of "fines" contained in the solvent-oil extract produced with this equipment can be removed by simple filtration. Whereas commercial plants employing direct solvent extraction of cottonseed have generally been unable to reduce the oil content of the extracted meal to 1.0 percent, or to avoid the formation of "fines" during extraction, operation of this pilot plant has shown that both objectives can be accomplished at rates comparable with those employed in commercial plants. The pilot plant has also been employed to prepare large quantities of oil and meal for use in other investigations such as oil processing, protein production, and the fractionation of cottonseed.

Batch solvent extraction plant. A pilot plant was designed, installed, and operated for a number of years to produce oil and meal from lots of cottonseed up to 120 pounds each, to evaluate cooked and uncooked flakes for solvent extraction, to obtain cottonseed oil-solvent mixtures for use in solvent recovery investigations, to evaluate various commercially available solvents including hexane, methyl pentane, benzene, acetone, methyl ethyl ketone, and ethyl ether as extractants for cottonseed oil. It has found wide application as an adjunct in work reported under other projects.

Oil processing pilot plant. An oil-processing pilot plant has been installed for refining, bleaching, deodorizing, hydrogenating (hardening), fat-splitting, and otherwise reacting cottonseed oil in approximately 55-gallon lots. The plant is used to process oil produced by solvent extraction, hydraulic and screw pressing, and for the preparation of large lots of oils for further research and development investigations, and for practical testing in industrial applications.

Protein production pilot plant. A pilot plant was designed and installed to produce protein, spent meal, and whey from solvent-extracted cottonseed meal in quantities necessary for further research and development work, and for the practical testing of these materials in various industrial and nutritional products being investigated under other projects. During operation of the pilot plant for the above-mentioned purposes, information was obtained on processing conditions and chemical engineering operations and applied to improving the process itself.

RESEARCH PROJECT RRL-2-(3)-E-5.

Miscellaneous engineering services. The major portion of the work of this project consisted in providing engineering services of routine and specialized nature in support of accomplishments reported under other projects. Some specific services rendered under this project have been: (1) installation of a 1250 cu. ft. walk-in cooler for storage of cottonseed samples at low temperatures; (2) procurement and installation of large exhaust fans to handle a total of 75,000 cubic feet of air per minute, and ventilate the area in which flammable solvents are handled for solvent extraction of cottonseed; (3) design and installation of storage building for flammable solvents used in cottonseed research; (4) maintenance of a catalog file on products and equipment of about 2500 manufacturers for use of workers on all projects.

RESEARCH PROJECT RRL-2-(3)-A-4.

(The major portion of the work of this project has consisted in providing analytical-chemical, physical-chemical, and physical evaluation and testing services of routine and specialized nature which have contributed materially to the achievements reported under other projects covered in this report.)

Storage of cottonseed. It has been shown that cottonseed can be preserved for several years with little or no change in chemical composition and germination if stored in sealed containers at temperatures below 1° C. and at moisture contents of 8.3 percent or lower. Such storage is not practical for commercial purposes but is satisfactory for preserving research and genetical lots of cottonseed.

Germination and free-fatty-acid content of cottonseed. It has been demonstrated that individual cottonseeds containing more than one percent free-fatty-acid will usually not germinate. Subsequent investigations in cooperation with the Arkansas State Plant Board indicated that, insofar as practical, cottonseed reserved for planting should have a low free-fatty-acid content (preferably less than 0.75 percent in the oil) to assure storable stocks of seed with a high percentage of germination.

Determination of inorganic phosphorus. A method for the determination of inorganic phosphorus has been developed for the determination of the distribution of phosphorus in plant materials. In addition to its use on cottonseed and derived products, it is being widely used in investigations on other plant materials.

Bromine retention in methyl bromide-fumigated cottonseed. It was demonstrated that no residual bromine remains in oil processed from cottonseed previously fumigated with methyl bromide to control pink boll worm. Seed treated with methyl bromide were processed by methods used in industry and the products subsequently examined for residual bromine. This work, which was conducted in cooperation with the Bureau of Entomology and Plant Quarantine, has justified the extension of the use of methyl bromide for fumigation of cottonseed in pink boll worm infested areas.

Determination of gossypol pigments. Three precise and practical methods, suitable for routine use, have been developed for the determination of gossypol pigments. One method is for the determination of free gossypol pigments in cottonseed kernels, cake, and meal. It has been adopted as official by the American Oil Chemists' Society and is used by more than 15 organizations engaged in processing or investigations of cottonseed. Another method is for the determination of total gossypol pigments in cottonseed kernels, meal, and cake. The third method is for the determination of gossypol pigments in cottonseed oil. These methods provide the analytical means necessary to obtain a gossypol material-balance in processing cottonseed to improve the nutritive value of the meal.

Viscosity and density data on cottonseed oil. Basic data on viscosity and density of cottonseed oil, hydrogenated cottonseed oils hardened to different iodine values, and cottonseed oil-solvent mixtures, over practical ranges in temperatures have been determined. Density-composition data for cottonseed oil-solvent mixtures have been developed for application in determining the composition of unknown mixtures of oil and solvent. These data are applicable in all types of processing operations in which a knowledge of viscosity or density as a function of temperature are required.

Physical-chemical data applicable to cottonseed salad oil process. The ratios of solid-to-liquid portions of cottonseed oil dissolved in acetone and petroleum solvents and in mixtures of these solvents have been obtained at reduced temperatures for use in the pilot plant development of solvent-winterized cottonseed oil (production of oils that will not partially solidify at refrigerator temperatures). The work has involved investigation of the influence of concentrations of oil in the solvent, temperature, holding-time, and iodine value of the original oil on the degree of winterization of the winterized oil.

F. Some Additional Work Needed

Fatty acid derivatives. The most pressing need in connection with the development of new uses and outlets for cottonseed, as well as most other vegetable oilseeds, is information on the derivatives of the fatty acids derivable from their constituent oils. The potential outlets for fatty derivatives in the manufacture of plastics, plasticizers, synthetic resins, surface active agents, drilling muds, water proofing agents, synthetic wax products, etc., is very great, but they are dependent on investigations involving the preparation and testing of the multitude of theoretically possible products derivable from fatty acids.

Upgrading cottonseed oil soapstock. More than 6 percent of all the crude cottonseed oil produced in the United States appears eventually as soapstock and approximately 70,000,000 pounds of dry fatty material annually goes into this byproduct of cottonseed oil refining. Difficulties have beset the processors of cottonseed oil as a result of a reduction in the price of cottonseed soapstock from 5-6 cents a pound to 1 or 2 cents a pound. This reduction in price reflects to some extent the reduction in fatty acids of cottonseed oil soapstock and the increased difficulty of recovering such acids as are present in this material, a condition brought about by the introduction of continuous screw presses for expressing the oil from cottonseed and of continuous methods of refining. Cottonseed oil soapstock also contains in concentrated form, sterols, vitamin E, and probably other useful components which have heretofore never been recovered. New fatty-acid-recovery processes and the possibility of isolating new products from cottonseed oil soapstock, are urgently in need of investigation, because the losses resulting from the presently depreciated soapstock will either be passed back to the farmer or forward to the consumer of the finished oil.

Improvement of stability of cottonseed oil. Although the advances made in stabilizing cottonseed oil have resulted in marked improvement in the quality of this fat and many of its derived products, there are a number of special uses, particularly certain types of consumer goods (deep-fat-fried foods such as potato chips, nuts, doughnuts, and prepared dough mixes), for which even greater stability is required than is now found with the most stable forms of this fat.

Extended research on the chemical preservation of stored cottonseed. Screening investigations of a large number of chemicals to determine their potential ability to inhibit deterioration in stored cottonseed has been completed. Additional work is needed to determine whether it is possible to increase or prolong the preservative action of the known active compounds. The supplementary effects, if any, of heat and of a fungicide should be investigated; likewise the best time to apply such supplementary treatments prior to storage or planting of the seed. It is essential to determine the effect of any given chemical treatment applied to the seed on viability, survival of seedlings, vigor of growth, yield of seed, quality of fiber, color and content of free fatty acids of oil, and the nutritional value of the seed and seed fractions. Studies of this type need to be carried through two or more generations of the treated seed. Toxicity of the chemical for man and animals must be determined if the treated seed or any of its fractions or products are to be used in foods and feeds.

Enzyme systems in cottonseed. Systematic studies of the enzyme systems in seed, particularly those that appear to be active in initiating and accelerating seed deterioration, are needed. The status of these enzyme systems in the seed at different stages of maturity, for different kinds and degrees of damage and for different intervals and conditions of storage should be known. Such information would make it possible to develop simple tests to determine the state of maturity of the seed and its tendency to undergo deterioration. Such tests could be of practical value to the producer and processor. Information should be obtained on the enzyme systems which are responsible for the formation of free fatty acids, and the development of undesirable odors and colors in oil products, as well as on the mechanism by which the systems act and the factors responsible for their action. Only by such knowledge will it be possible to arrive at a satisfactory method for completely preventing deterioration of stored cottonseed.

IMPROVEMENT IN METHODS OF COTTONSEED-OIL EXTRACTION, DEVELOPMENT OF NEW AND IMPROVED PRODUCTS FROM COTTONSEED AND THEIR EVALUATION

(BAIC, BAI, BDI, and BHNHE - RM:a-103 - Federal-State - RMA Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To develop new and improved methods of handling and processing cottonseed and its byproducts and derived products by the application of chemical, physical, biological, and engineering principles and methods; and to develop new and improved uses and new and extended markets for products derived from cottonseed. The current work is concerned with a broad survey of the composition of cottonseed as influenced by environment and variety. Engineering research is being conducted on the development to a commercial scale of the method for fractionation of cottonseed kernels into oil, meal, and pigment glands. Chemical research is being conducted on utilization of pigment glands and derived products and on improvement in the nutritive value of the meal by changes in conditions of processing. Contract engineering research is under way on improvement of screw- and hydraulic-press extraction of cottonseed oil and solvent extraction of whole rolled cottonseed. The manner in which seed deteriorates during storage is being investigated by treatment with synthetic compounds containing radioactive elements.

B. Currently Active Line Projects

RM:a-103-1 - Composition of cottonseed as influenced by environment and variety. To contribute to the improvement of cottonseed as a source of oil, meal, and protein for industrial, food, and feed uses by evaluating the influence of environment and variety on the composition of cottonseed through the physical and chemical analysis of 8 varieties of cottonseed grown at 13 field stations during 3 growing seasons. Cooperative with the Bureau of Plant Industry, Soils and Agricultural Engineering.

RM:a-103-2 - Pilot-plant separation of cottonseed meats into oil, meal, and pigment glands. To develop on a pilot-plant scale a feasible process for the commercial separation of cottonseed meats into high-grade oil, a highly purified and nutritious meal, and pigment glands, with the objective of widening the outlets for cottonseed meal and making available new byproducts (pigment glands and gossypol) as additional source of revenue. Research in cooperation with a cottonseed-processing company is directed toward commercialization of the process.

RM:a-103-3 - Development of products that have industrial and pharmaceutical value from cottonseed-pigment glands. To develop new uses and extended markets and outlets for cottonseed pigment glands and their derived products. Particular attention is given to uses for gossypol, which is the principal pigment of cottonseed. Pharmacological investigations on these products are made in cooperation with a cottonseed-processing company and two universities.

RM:a-103-4 - Influence of methods of processing upon the nutritive value of cottonseed meal. To extend the use of cottonseed meal as a livestock feed and human food through the improvement of existing methods and development of new methods of processing. The processing experiments are being made by cooperating cottonseed-oil companies, and some nutritional experiments by a cooperating state agricultural experiment station. Nutritive evaluation experiments are also carried out by the Bureau of Human Nutrition and Home Economics, Animal Industry, and Dairy Industry under line projects 103-7, 103-9, and 103-15, listed below.

RM:a-103-7 - The effects of different methods of processing cottonseed meal on its protein nutritional value. To determine the protein digestibility, the content and availability of nutritionally essential amino acids, and the biological value of cottonseed meals processed under controlled conditions by various methods. The meals are prepared under line project 103-4.

RM:a-103-9 - The nutritive evaluation of cottonseed meals for the feeding of poultry, swine, beef cattle, and other livestock produced by new and improved processing procedures. To evaluate by means of feeding tests, with poultry and other classes of livestock, the nutritive values of cottonseed meals produced by new and improved processing procedures in order to help determine the best procedures for general use in oil mills. The meals are prepared under line project 103-4.

RM:a-103-10 (C) - Improvement of the process for hydraulic pressing of cottonseed. To determine on a laboratory scale in a manner applicable to mill-scale operations the best conditions and procedures for cooking and pressing cottonseed and to obtain the best quality and yields of the products. This research is conducted under contract at a State engineering experiment station.

RM:a-103-11 (C) - Solvent removal of oil from cottonseed and subsequent separation of linters, hulls, and meal. To determine the commercial feasibility of solvent extraction of oil from cottonseed prior to the removal of linters. This research is conducted under contract with a state research organization.

RM:a-103-12 (C) - Improvement of process for continuous screw pressing of cottonseed. To improve the process of screw-pressing cottonseed in order to obtain better yields and high-grade end products on an economical basis. This research is conducted under contract by a State engineering experiment station.

RM:a-103-13 - Investigation of chemical treatment of cottonseed by means of radioisotopes. To investigate biological changes in cottonseed, resulting from chemical treatment, by histochemical examination of seed sections and use of radioisotopes. The chemicals are "tagged" with radioactive isotopes to permit fundamental investigation of the reactions occurring in seeds.

RM:a-103-15 - Vitamin B_{12} activity of and unidentified nutrients in variously prepared cottonseed products. To determine the vitamin B_{12} activity of various cottonseed products produced under known conditions and to determine the absence or presence of unidentified nutrients in such products. The products are prepared under line project 103-4 of BAIC.

C. History and Evolution of This Work

Funds made available under this project, beginning with the 1948 fiscal year, have permitted an expanded research program on cottonseed. Several phases of the work are applications of preliminary or fundamental research conducted during the period 1941-1947 under regular funds, as for example, the work on fractionation of cottonseed meals. Also, research on gossypol and on the nutritive value of cottonseed as effected by conditions of processing had its origin in work begun before Research and Marketing Act funds became available.

Under this project, attempts are being made to evaluate the various cottonseed meals, produced by new and improved processing procedures, as feed for poultry, swine, and other classes of livestock. Cottonseed meal is an important and valuable protein supplement for the feeding of cattle and sheep, but in swine feeding it has ranked below a number of other oil meals because of toxic effects and because of lower biological value of the protein. In the case of poultry, some of the same defects, plus discoloration of egg yolks during storage of the eggs, have lessened its value.

Feeding experiments with small animals has demonstrated that the protein value of a cottonseed meal unimpaired by heat treatment, and free from the toxic substance gossypol, is considerably higher than that of heat-treated commercial cottonseed meal. The recent development of microbiological assays suitable for the determination of many of the essential amino acids has permitted the present study to include determinations of the amino acid content of the meals in addition to determinations of the nutritional value of the protein of the meals by rat-feeding experiments.

The ability to contract for some phases of the research aids the effectiveness of the current research program. As indicated in Section B (above), important phases of the project are being conducted under contract with organizations outside the Department that have facilities easily adapted to the requirements of the research.

D. Funds--Annual Expenditures

Expenditures by four Bureaus for the fiscal years 1948, 1949, and 1950 were as follows:

	1948	1949	1950
BAIC	$84,300	$125,800	$156,900
BAI	-	4,000	10,000
BDI	-	1,500	5,000
BHNHE	-	5,000	10,000
Total	$84,300	$136,300	$181,900

E. Examples of Outstanding Accomplishments

Fractionation (separation of components) of cottonseed meals. A new and novel method of processing cottonseed has been developed to the point for pilot-plant demonstration. One of the products is a highly purified meal that is practically free from toxic pigments, and may find extensive use in feeds and industrial products. A 10-fold concentration of the pigments in the gland fraction is a potential source of gossypol, a chemical that has interesting and possibly valuable properties, but was not previously available in quantity.

Useful products from pigment glands. New compounds, formed by combining gossypol with peanut protein, amino acids, dextrose, or starch, have been made and furnished to a number of pharmacologists for determination of their effects on experimental animals. They are lethal to goldfish in concentrations of 1 part in 100,000 parts of water, whereas gossypol itself is not lethal at all, and pigment glands that contain gossypol in its natural state are not quite as toxic as the new compounds. When these compounds are stored at elevated temperatures, pigment changes take place similar to those that occur in stored cottonseed. The new compounds provide means for the investigation of the physiological action of gossypol as it occurs in the natural state, and of the changes that take place in gossypol and the gossypol pigments on storage of the seed.

Variability of chemical properties of cottonseed meal demonstrated. Numerous cottonseed meals, including commercial hydraulic-pressed, screw-pressed, and solvent-extracted meals, were analyzed for gossypol content and soluble nitrogen. The choice of determinations to be made was based on the realizatio that the food value of cottonseed meal depended on two factors: (1) the amount of toxic material -- free gossypol-like materials -- in the meal, and (2) the protein value. The analyses showed that there was considerable variation in the gossypol content of these meals and also in their soluble-nitrogen content. The results thus demonstrated the inadequacy of the present methods of labeling cottonseed meal for feed purposes.

Production of cottonseed meal of higher nutritive value. Research in cooperation with a cottonseed processing company showed that the composition and properties of the meal are influenced by the cooking and pressing conditions. When the conditions of cooking are mild, the amount of soluble nitrogen in the meal depends upon the energy input to the screw-press as related to the output of oil and meal. Adequate oil yield was obtained with lower energy input into the press, and, therefore, it was possible to produce cottonseed meals containing more soluble nitrogen. Cooperative feeding tests with screw-pressed meals produced under mild conditions of processing showed that such meals supported growth at a rate 50 percent or more higher than for normal meal, when fed to chicks and hogs. The research is continuing as cooperative work between State and Federal laboratories. It has been estimated that an increase of 1 percent in the nutritive value of the meals may be worth 1 million dollars per year.

Cottonseed meal produced under conditions of minimum heat damage. An extensive investigation was made of the types of solvents that may be used to reduce gossypol content to a minimum so as to produce a cottonseed meal of low toxicity and high protein value. This investigation showed that methyl-ethyl ketone containing up to 10 percent water is the best of the known solvents for removing gossypol. Extensive laboratory investigations have been made to determine the optimum conditions of use of this material for extracting the gossypol from cottonseed meal.

Vitamin B_{12} content of cottonseed flour. Samples of defatted, deglanded cottonseed flour and of screw-press cottonseed meal were found to be deficient in vitamin B_{12} when fed in the diet of rats at levels of from 20 to 79 percent. When supplemented with ample vitamin B_{12}, some of these rations, which contained adequate amounts of all other known nutrients, yielded results which indicated that these cottonseed products may be deficient also in an unidentified nutrient.

Cottonseed flour as an inexpensive source of protein. Comparisons were made of 10 percent of dried heat-coagulated egg white and 20 percent of a sample of defatted, deglanded cottonseed flour (equivalent to 10 percent of protein) as the sole source of protein in B_{12}-deficient rat rations containing adequate amounts of all other known essential nutrients. Upon supplementing each of these rations with the same quantity of vitamin B_{12}, the cottonseed flour resulted in slightly greater growth than the egg white, thus demonstrating that cottonseed is an inexpensive source of protein.

The nutritive value of the protein of cottonseed meals can now be evaluated by a bacterial assay method which correlated closely with the findings obtained by animal feeding. By means of this method, as well as by means of rat-feeding tests, evidence has been obtained for marked changes in the cottonseed protein as the result of various processing treatments. This new assay method is valuable as a research tool, since it saves much time and expense in determining nutritive values.

Evaluation of cottonseed meal as protein supplement for growing chickens and pigs. Cottonseed meals, processed by commercial methods under the widest possible range of cooking conditions consistent with good oil yield, were fed to growing chickens as 39 or 70 percent of the diet. From the standpoint of over-all nutritional value, screw-pressed meals obtained under certain conditions proved satisfactory. The variation in gossypol contents of the various meals was reflected in the growth of chickens fed diets containing 70 percent of cottonseed meal but not in the growth of those fed 39 percent.

Screw-pressed cottonseed meal processed by cooking at the proper temperature proved as satisfactory as soybean meal when used as the main source of protein for growing and fattening pigs, while a hydraulic-pressed cottonseed meal was significantly inferior under similar testing conditions. The findings on chickens and pigs, showing that screw-pressed meals of relatively high nutritive value can be obtained, thus justify marked increase in the use of cottonseed in feeds.

F. Some Additional Work Needed

Fractionation (separation of components) of cottonseed meats. Additional engineering development is required to improve the yield of purified meal from the fractionation process to 85 percent or more and to concentrate the pigment glands in the smallest amount of meal possible. The purified meal should be assayed as human and animal food. The information gained will permit an evaluation of the industrial feasibility of the fractionation process.

Production and reactions of gossypol. Additional work is needed to develop a commercially practicable process for the production of gossypol at a moderate cost. Few compounds of gossypol should be made and evaluated in pharmacological tests. By such means it may be possible to find a valuable use for this material. The method by which gossypol is detoxified when it is brought in contact with the meal should be determined. This can be done in part by investigating the reactions of pure gossypol with proteins and other seed constituents.

Improvement of nutritive value of screw-pressed cottonseed meals. All of the experiments on producing more nutritive cottonseed meals by using mild cooking conditions and low power for screw-pressing were made in one cottonseed-oil mill in Texas. It is desirable that confirmatory work be done at widely separated screw-press mills having different types of equipment and operating on seed grown under different conditions. When sufficient information is available from these widely scattered experiments, it should be possible to draw conclusions as to how variations in screw-press operation effect the quality of the residual meal to devise practices that would be most generally applicable. Additional information is also needed on the effects of changing the conditions of processing on the value of the oil.

Universal method of cooking cottonseed meals. Research is needed to develop a universal method of cooking that will detoxify cottonseed under minimum requirements of heat. Such a method would insure the production of cottonseed meals of low toxicity and minimum damage to the protein by any known method of cottonseed processing. Progress already made in improving the screw-press method of processing could then be extended to the hydraulic and solvent-extraction methods, as well.

Laboratory method for evaluating cottonseed meal. It is desirable to develop a rapid chemical method for estimating the probable nutritional value of cottonseed meal. This method would have the following advantages: (1) It would make possible the selection of meals having high nutritional value and thus permit considerable screening prior to submission of meals for the more expensive confirmatory nutritional evaluation by feeding tests; (2) it would facilitate efforts by the oil miller to control his processing so as to produce the best possible product; (3) it would make it practical to give more information about the nutritive value of the meal on the label, so that feed dealers and users would have more adequate knowledge of the type of material they are purchasing.

A study of the manner in which cottonseed protein is changed during processing, from the standpoint of effect on the essential amino acids available for human nourishment, is of utmost importance not only when applied to the cottonseed problem but also when applied to all processed foods.

Gossypol-toxicity studies. Information is needed on the tolerance for gossypol of various species of animals. This is important in evaluating various cottonseed meals on the basis of chemical determination of gossypol.

CROSS REFERENCES - UTILIZATION

For additional information on subjects reported in this chapter, see also:

BHNHE No. b-3-6, Chapter 25, properties of fabrics as related to selection, care, and use.
BAIC No. RRL-5-3, Chapter 38, utilization of flax and other fiber residues.
BHNHE No. RM:a-341, Chapter 25, family utilization of clothing and household textiles.
BHNHE No. b-3-7, Chapter 25, clothing and household textile articles.
BAI No. b-6-2, Chapter 3, cottonseed meal in poultry diets.

COTTON GINNING INVESTIGATIONS
(BPISAE - e-3-1 - Federal-State-Regular Funds)

A. Purpose and Nature of Current Work

To develop better ginning equipment and techniques that will increase gin turnout of cotton fiber of better quality. Ginning in its simplest form, consists of preliminary screening to remove foreign matter, the pulling of the lint from the seed, the packing of the lint into bales, and the recovery of the seed. These operations may, and often do damage some of the desirable natural qualities of the lint, with a consequent lowering of the price. Specifically the project aims, (1) to discover the fundamental laws of cotton conditioning, cleaning, extracting, ginning, and baling, (2) to design, build, and test equipment based on such laws, (3) to develop new methods and practices whereby each operation will be facilitated by closer adherence to such fundamental laws, and (4) to test and demonstrate such improved devices and practices in the interest of better ginning and lessened damage to the quality of lint and seed. The work is carried on as a cooperative project between the Division of Mechanical Processing, B.P.I.S.A.E., and the Cotton Branch, P.M.A., in which the engineers assume responsibility for developing and testing new equipment and processes while the technicians of the Cotton Branch determine the effect of such new processes on the quality of the fiber. R.M.A. funds have been used for certain specific problems falling within the general field of this project.

B. Currently Active Line Projects

e-3-1-1 - Cotton gin stand research - the reciprocating noting device.

To invent a device to be installed in a gin stand immediately behind the gin saws to agitate, scrub, and screen the lint in such a way as to remove notes and foreign matter without unduly injuring the lint.

e-3-1-2 - Determination of moisture content for optimum operation of ginning equipment. To determine the optimum moisture conditions for cleaning, ginning, and packaging cotton, develop means of maintaining these moisture conditions, and devise methods of quickly and automatically changing moisture contents as the cotton passes from one process to another.

e-3-1-3 - Develop a device for removing sticks from seed cotton before ginning. To develop devices and techniques for extracting sticks from seed cotton as it enters the cleaners and before the sticks and branches are ground up into many small pieces in order to facilitate the cleaning process.

e-3-1-4 - Develop a device for removing green bolls from seed cotton before ginning. To develop a means of removing green and immature bolls from seed cotton during the cleaning process, thus removing a source of trash, of green stains on the lint, and of neppiness in the fiber. There is also included the further problem of reclaiming usable fiber from the bolls after they have been removed from the cleaner.

e-3-1-5 Bulk seed cotton feeding control. To design an automatic regulator which will feed seed cotton into the ginning system at a uniform rate, thus preventing over-machining and consequent loss of grade.

e-3-1-6 - Foreign matter disposal at gins. To find an economical use for gin waste, hulls, leaves, stems, and trash by reducing to producer gas for power production, concentrating for use as fertilizer and other possible uses.

C. History and Evolution of the Work

Realizing the importance to the farmer of securing better ginning, the Congress established the U. S. Cotton Ginning Laboratory at Stoneville, Miss. in 1930. Some preliminary work was done before that at Tallulah, La., and other points, but 1930 marked the establishment of the laboratory. The project was a cooperative one between the Bureau of Agricultural Economics, the Bureau of Agricultural Engineering, and the Mississippi Agricultural Experiment Station. Under the terms of the initial agreement, the State transferred the site to the U.S.D.A., the Bureau of Agricultural Engineering assumed responsibility for the mechanical aspects of the problem of developing better ginning machinery, and B.A.E. responsibility for the tests of fiber quality by which the mechanical improvements were evaluated. During these 20 years a rather complete ginning laboratory has been built up, including virtually all standard commercial types of gins and accessories so that experimental equipment, new devices and processes can be tested under full operating conditions. The fiber laboratory is equipped to determine the effect of the mechanical improvements upon fiber quality.

D. Funds--Annual Expenditures

The original appropriation for the engineering part of this program was $85,000 for fiscal year 1931, which covered considerable building and equipment expense. In 1932, the appropriation was $55,000, in 1933, $48,630, and about $35,000 during the latter 30's. Since then there has been a gradual increase to $80,880 in 1950.

E. Examples of Outstanding Accomplishment

The Cotton Ginning Laboratory has established itself as the outstanding authority on cotton gin equipment and operation. The manufacturers of gin machinery and the operators of commercial gins bring their problems to the project leaders for help and advice. There is hardly a modern gin which is not using one or more of the improvements originated at the Laboratory. Since 1943, the U.S.D.A. Extension Service has employed two extension specialists to carry the results of the Laboratory's work to State organizations and directly to cotton ginners. Ten of the cotton states employ extension specialists, trained at the Laboratory, and cooperating with the Federal Specialists to further the use of improved ginning equipment. Each year hundreds of cotton ginners, growers, merchants, and spinners visit the laboratories to secure technical assistance.

The development of a seed cotton drier. The Government process for drying seed cotton was first patented in 1928, and since then various improvements have been added. In 1935, 210 gins were using driers; in 1940, 1419 had them; in 1945, the figure was 3093; and in 1950, it

Page 123, substitute the following copy for second and third full paragraphs:

Standard density presses. It has long been recognized that present methods of packaging cotton are inefficient and wasteful. The present practice is to package lint cotton at the gin in bales of low density (about 12 pounds per cubic foot), ship the bales to a compress where they are repressed to standard density (about 22 pounds) for domestic shipment or to high density (about 32 pounds) for export. A gin press which produces "standard density" bales suitable for all domestic shipments was developed and thoroughly tested at the Ginning Laboratory. Complete details with respect to this type have been installed at several commercial gins where both the economic and mechanical feasibility of gin standard density compression have been demonstrated under commercial ginning and marketing conditions. An important feature of gin standard density compression is the superior bale package thus afforded — superior from the standpoint of uniformity in bale shape and dimensions as well as of protection of the bale contents.

Plate Dogs. Conventional methods and practices of packaging lint cotton at gins often result in bales of uneven density which show up in the market as "air cut", "big ended", or "rolling bales." Research developed the fact that uneven density was largely due to the formation of "dog ridges" during baling. A continuous plate dog was invented and patented which is adopted to "up-pack" gin presses (the type of presses used in the majority of United States gins). If and when it is used on such presses, it would correct the problems of uneven density and, in turn, big-ended or rolled bales.

gin standard density compression

commercial ginning and marketing conditions. An important feature of gin standard density compression is the bale p thus afforded, which is superior from the standpoint of uni formity in bale shape and dimensions as well as protectio the bale contents.

Page 184, insert as last line of page: "time of National emerg Research on flax and hemp has been--"

Chapter 11, first line of third paragraph should read "RM:a-556-10 instead of "RM:a-566-10".

Chapter 13, page 44, fifth line of item E, change $2,500,000 to $3,

Page 67, second line of project b-11-1-6, change the word "var to "species".

Chapter 14, page 109, delete the word "pending" from the four line

Chapter 16, page 16, in the heading for item C, change "Evaluation" "Evolution".

Chapter 21, page 21, delete last sentence of first paragraph under

Page 30, delete last sentences of third and fourth full paragra

Page 34, delete the third and last sentences of the last pa

Page 36, delete the second paragraph; also last sentence of third paragraph.

Page 229, second line of item D, insert "annually" after $40 is probable 5,000 gins out of an approximate total of 9,000 will be using Government-type driers.

Small pipe conveying system. Cottonseed is taken from the gin saws and conveyed by air to trucks or to storage bins. In an average commercial gin, the seed conveyor pipes were about 12 inches in diameter. The laboratory engineers developed a small pipe system requiring from 3 to 7 h.p. as compared with 10 to 15 with conventional systems for moving equal amounts of cotton seed. Over 500 have been installed in commercial gins.

~~Standard density presses. It has long been recognized that existing practices of packing cotton are wasteful and inefficient. The existing practice is to compress the lint cotton at the gin to "low density" (11 lbs. per cu. ft.), and then ship this bale to a compress where it is re-pressed to "standard density" (22 lbs.) for domestic use or to "high density" (33 lbs.) for export. Experimental presses have been developed under this project which produce economically "standard density" bales at the gin. Six commercial gins are using this press. The use of this press halves the space needed for storage, saves freight charges, and makes it possible for the cotton to go directly to domestic mills without the delays involved in present practices.~~

~~Plate dogs. Conventional methods and practices of packaging lint cotton at gins often result in bales of uneven density which show up in the market as "air cut", "big ended", or "rolling bales." Research developed the fact that uneven density was largely due to the formation of "dog ridges" during baling, and a continuous plate dog was invented and patented which gives bales of uniform density.~~

Lint flue cleaner. The grade of cotton lint is largely determined by the amount of fine trash which it contains. Because of its light and fluffy condition the best place to remove this "pepper trash" is immediately behind the gin saws since never again will the lint be as light, fluffy, and buoyant. After many trials and years of basic research, a new type of cleaner was designed for installation just behind the gin stand and called a "lint-flue cleaner." Over 500 cleaners, based on the Laboratory's work, were in commercial use in 949 and increased the grade of the cotton from 1/3 to 1/2 grade ithout appreciable damage to its spinning qualities. From 1200 to 1500 lint flue cleaners will be in use in the 1950 cotton season.

Some Additional Work Needed.

Waste heat recovery. A great deal of heat is generated during the ginning process, used and released in the open air. In many gins, heat is used in drying seed cotton, lint, and seed at one or more locations, and having served its purpose is dissipated. Studies should be made of efficient methods of saving as much as possible of this heat and put it to some good use. Some practical means of collecting, compressing, and reusing waste and surplus heat would do much to reduce the costs of ginning.

Auxiliary gin enterprises. One of the economic handicaps to gin operation is the seasonal nature of the business. Most gins operate only 3 or 4 months per year, and for the remainder of the time the equipment stands idle, and the workers secure other employment. There is need for investigating the possibilities of year-around operation by using the whole or part of the power unit in operating other rural processing facilities, e.g., canneries, or by producing cotton products which can be made without spinning at the gin, or in some other way provide more continuous operation, thus reducing overhead charges and furnishing permanent employment to the technical staff.

DEVELOPING IMPROVED EQUIPMENT AND TECHNIQUES FOR GINNING AND ASSOCIATED PROCESSES TO MINIMIZE LOSSES AND INCREASE SALABILITY OF COTTON AND COTTONSEED

(BPISAE - No. RM-a-71 and PMA - RM-c-71 - Federal - State - RMA Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to develop improved equipment and techniques for cotton ginning and associated processes that will enable the ginning industry to preserve the inherent qualities of lint and seed and to provide services as required by cotton producers under changing conditions of cotton production and harvesting.

The ginning industry of this country is now in process of transition from an industry employing relatively simple mechanical equipment in small plants to a larger-scale industry requiring complicated mechanical equipment and processes to cope with changes in production and harvesting. Intensive research is needed to enable the ginning industry to provide services as required by cotton producers under changing conditions.

The work of this project differs from the research being conducted by the same Federal agencies with regular funds at the U. S. Ginning Laboratory located at Stoneville, Miss. The work under regular funds covers research on basic ginning processes whereas this project is confined to such special items as the conditioning and storage of mechanically harvested seed cotton prior to ginning, special problems of ginning peculiar to specific cotton-producing areas, the conditioning of cottonseed at gins, the development of new principles of cleaning cotton and other problems occasioned by changing conditions in cotton production and harvesting.

B. Currently Active Line Projects

RM-c-71-1 (PMA), RM-a-71-5 (BPISAE) Conditioning and storage of seed cotton with special reference to mechanically harvested cotton. The ginning of machine-harvested cotton is complicated by the excessive moisture content of such cotton and by the fact that it can be harvested so much faster by machine than it can be processed at existing gins. The ginning industry is faced with the alternatives of providing increased capacity which would be used during a shorter season or of developing facilities and methods for storing and conditioning the seed cotton for proper ginning after a period of storage. This project is designed to evaluate the effect of different types and lengths of storage on the quality of both lint and seed and the comparative economies of the alternatives facing ginners in areas where mechanical harvesting is practiced.

RM-a-71-4 (BPISAE), RM-c-71-8 (PMA). Study of principles and methods of removing foreign matter from seed cotton based on recent developments in other sciences. The purpose of this project is to explore possibilities for adapting new principles to the removal of foreign material from seed cotton prior to ginning. Among the new principles upon which work is being done are aerodynamics, high frequency vibration, and electrostatic attraction. The work is being done under contract by a private research institution.

RM-c-71-7. Storing as an aid to more efficient ginning and marketing of mechanically-harvested seed cotton. (Being conducted by the Texas Agricultural Experiment Station) The objective of this project is to study the advantages and disadvantages of storing seed cotton on the farm and at the gin. Questionnaires concerning experiences with seed cotton houses are being sent to all ginners in Texas, and gins with larger cotton houses will be given more intensive study.

RM-c-71-9 (PMA). Development of equipment and methods for conditioning, cleaning, and handling of cottonseed at gins to preserve viability and milling quality. RM-a-71-11 (BPISAE). Cottonseed conditioning, cleaning, and handling at gins. This project is concerned with the development of equipment and methods of artificially drying cottonseed at gins to retard deterioration but without injury to the viability of the seed or to the quality of the milled products, and the adaptation of such equipment and methods to cotton ginning and seed handling and storage operations.

RM-c-71-10 (PMA). Research on ginning problems peculiar to the low humidity areas of the western cotton-producing States. RM-a-71-12 (BPISAE). Evaluation of different effects of ginning processes and methods on irrigated cotton. One reason for the establishment of the U. S. Cotton Ginning Branch Laboratory at Mesilla Park, New Mexico, was to adapt the new inventions and processes developed at the Stoneville Laboratory to use with irrigated cottons. In general, irrigated cotton fibers are longer and finer than rain-grown cottons, and the atmosphere and the cotton itself are much drier than in other areas. Hence it will be necessary to alter or adapt the ginning equipment developed at the Stoneville Laboratory to make it useful in irrigated areas.

RM-a-71-13 (BPISAE). Control of static electricity at gins. Under some conditions in all parts of the Cotton Belt, static electricity develops within the gin machinery, choking the flow of cotton, making baling difficult, and presenting a serious fire hazard. Such conditions occur quite frequently in the arid and semiarid sections of the Far West and Southwest. This project is concerned with the development of means for the control of static during ginning.

C. History and Evolution of This Work

The first work initiated in fiscal year 1948 covered the conditioning and storage of mechanically-harvested seed cotton. This project is practically complete, awaiting only some further tests on very wet cotton and the completion of the report.

Funds for the construction of a building for the Cotton Ginning Branch Laboratory at Mesilla Park, New Mexico, did not become available until fiscal year 1949, and the machinery and equipment were obtained early in fiscal year 1950. The building, complete with all its equipment, was dedicated on December 17, 1949, and work immediately began. Part of the work under this project is being conducted under contract.

D. Funds - Annual Expenditures

Federal expenditures for this work have been approximately as follows:

	BPISAE, ARA	Cotton Branch PMA	Office of Experiment Stations	Total
1948	$ 22,200	$25,000		$ 47,200
1949	219,000	56,000	$4,400	279,400
1950	120,500	78,000	3,000	201,500

E. Examples of Outstanding Accomplishments

Determination of conditions required for storage of seed cotton prior to ginning to avoid deterioration of lint and seed. The conditions required for satisfactory storage of seed cotton prior to ginning and practical methods for attaining such conditions have been determined on the basis of extensive empirical tests.

A new type of equipment for cleaning seed cotton based on the principles of aerodynamics has been developed to the embryonic stage. Application has been made for a public patent on this equipment.

Establishment of branch cotton ginning laboratory for conducting research on special problems of ginning cotton in low humidity areas. Fully equipped facilities for conducting research on special problems of ginning cotton under conditions of low humidity have been provided at Mesilla Park, N. M.

Determination of safe limits of drying temperatures and periods of exposure of high moisture content cottonseed. Information with respect to drying temperatures and air volumes required for effective drying of cottonseed of high moisture content and safe limits of drying temperatures and periods of exposure, from the standpoint of viability and milling quality, has been developed on the basis of extensive empirical testing.

F. Some Additional Work Needed

Adapting and testing new gin equipment and techniques in different locations in the Cotton Belt. There is need for additional work to adapt the new ginning improvements developed at the U. S. Cotton Ginning Laboratory to the conditions existing in the different cotton-producing areas.

Fire prevention at gins. Each ginning season is marked by serious and costly fires in gins and in baled cotton in storage or in transit. It is thought that these fires may be caused by matches, steel or other metal in the seed cotton, static electricity, or other causes occurring within the gin even though the fire may not break out in the bale until after it has left the gin. Research is needed to determine clearly the causes of fires and means of prevention. Every possible means of identifying "hot bales" before they leave the gin should be fully investigated.

Elimination of big-ended bales. A number of things may singly or acting together cause a cotton bale to be unevenly packed with lint, resulting in a bale of uneven density. Possibly one end may be much larger than the other, or one side of the bale may be heavier than the other, or the center of gravity may be far away from the center of the bale. When such big-ended or lopsided bales get to the compress, they cause a hold-up in the production line in that many have to be taken out of the line, torn apart, and rebuilt. Research is needed to develop either equipment at the gin which will prevent the packing of uneven bales, or else compress machinery which will handle poorly made bales without the heavy expense involved by the present methods.

Cotton ginning branch laboratory to serve the Southeastern States. The Cotton and Cottonseed Advisory Committee at its meeting on March 1-2, 1950, "again went on record as favoring the construction of a branch cotton ginning laboratory to serve the Southeastern States, to be financed through specific congressional appropriation for the fiscal year 1952."

COSTS AND MARGINS OF COOPERATIVE COTTON GINS
(FCA - RM-c 438 - Federal-RMA Funds)

A. Purpose and Nature of Current Work

To analyze revenues, costs and margins of cooperative cotton gins to determine possible changes needed to affect economies and increase efficiency of operations. In order to properly evaluate ginning costs and expenses all revenues and margins must also be considered. Margins realized in buying and selling cottonseed and seedcotton, and for some gins' lint cotton, are considered in this study along with revenues and expenses incident to operating the gin plant. Ginning cotton and marketing cottonseed, and in some cases cotton, are joint enterprises with joint costs for practically all cotton gins. No satisfactory method is available for separating administrative costs between ginning proper and these marketing activities.

Uniform financial records have been obtained from 220 cooperative gins in 7 States for the 1947-48 and 1948-49 seasons. These records were taken from annual audits and included complete details as to revenues, costs and expenses. These audit records were supplemented by data from these same gins for 1949-50 on volume ginned by weeks in relation to total man-hours of labor employed each week.

The primary business of these cooperatives is ginning cotton and associated marketing services. Each cooperative gin is a separate and independent business. There is no administrative supervision from a parent organization as in line gins owned by cottonseed oil mills. On the other hand, the paid manager of the cooperative, unlike owners of private gins, usually has no other business activities or responsibilities. Thus financial records of these cooperatives represent ginning costs and margins both inclusively and exclusively.

B. Currently Active Line Projects

RM:c 438-1. Costs and margins of cooperative gins. To analyze revenues, costs and margins of a representative number of cooperative cotton gins.

C. History and Evolution of This Work

This current study is similar to one made by Farm Credit Administration some 15 years ago. Costs and margins of 95 cooperative gins in Oklahoma were analyzed for the 1933-34 operating season. Comparison of the results of these two studies shows changes that have taken place in costs and margins of ginning operations during that period.

Results of this current study of cooperative gins will be generally applicable to privately owned commercial gins. Cooperatives perform the same services and at the same competitive rates and prices as commercial gins. The initial ginning charges and cottonseed prices to farmers are exactly the same in either case. The only major difference is that cooperatives, in effect, adjust their initial rates and prices at the end of each fiscal year by distributing as patronage refunds the excess of total revenues above all costs and expenses.

D. Funds - Annual Expenditures

The fiscal year expenditures in conducting this project have been as follows:

1949	$11,200
1950	20,100

E. Examples of Outstanding Accomplishments

Utilization of labor. Many cotton gins waste half or more of the labor for which they pay during the operating season. For example, 27 Oklahoma cooperative 5-80 plants ginned 71,813 bales during the 1949-50 season and used an average of 3.78 man-hours per bale for labor and management. During their best week 2.28 man-hours per bale was used. A 5-80 plant with a full crew can gin cotton at the rate of 1.76 man-hours per bale under normal operating conditions. Thus these gins received no revenue from 53.4 percent of the labor for which they paid during the total operating season. Even during their best week 22.8 percent of the labor for which they paid was not utilized. Obviously, these results are due to intermittent operation throughout most of the season while the gin crew is paid on a daily stand-by basis. Labor and management expenses make up a third or more of total ginning expenses. At prevailing rates for salaries and wages this unused labor cost was approximately $2.00 per bale ginned. Stated another way, these 27 associations could have ginned more than twice as many bales in the same period of time and without hiring any additional labor had the cotton been available. This would have reduced other ginning expenses per bale although proportionally less than for labor.

Possible solutions to this problem are storage of seedcotton either on the farm or at the gin during the peak of the harvesting season, and similar storage in connection with reduced ginning days per week during the beginning and end of the harvesting season.

Margins on cottonseed. In most instances gins realize more net income per bale from handling cottonseed than from ginning the cotton. Over a period of years, and for plants with average volume, ginning revenues, including charges made for bagging and ties, tend to be about the same amount per bale as total operating expenses. Profits of commercial gins and savings of cooperatives are, for the most part, realized from handling cottonseed. For this reason any analysis of ginning revenues and expenses should consider margins realized on cottonseed.

The table below shows comparative revenues, margins and expenses of 5-stand cooperative gins in Oklahoma for 1933-34 and 1948-49 at 2,500 bales volume.

Items Compared	1933-34 Per Bale Ginned	1948-49 Per Bale Ginned	Increase 1948-49 over 1933-34
	Dollars	Dollars	Times
Revenue from ginning & wrapping	4.85	12.97	2.7
Margins on cottonseed and cotton	.91	3.91	4.3
Total revenues and margins	5.76	16.88	2.9
Total expenses, including B & T	4.44	11.65	2.6
Net gain, all operations	1.32	5.23	4.0

Over this 15 year period revenues per bale from ginning and wrapping, and also total ginning expenses, increased a little over 2½ times. For both seasons, at 2,500 bales volume, revenues per bale from ginning and wrapping was little more than total expenses. At volumes below 2,000 bales, average expenses per bale would have exceeded revenues.

Effects of volume on per bale expenses. This study confirms the results of numerous other studies of the importance of volume on per bale expenses. Total ginning expenses of 5-80 plants in Oklahoma during 1948-49, including the cost of bagging and ties, are shown below at intervals of 1,000 bales volume.

Volume in Bales	Total Expenses
1,000	$16.59
2,000	12.48
3,000	11.11

These data emphasize that any comparative analysis of ginning costs between plants of different size, or of plants differently equipped, must be made at the same volume since the difference in costs due to volume would overshadow differences in average costs for other variables being studied.

F. Some Additional Work Needed

Daily utilization of labor and analysis of margins. An intensive study is needed for a relatively few gin plants of daily operations. Daily volume in relation to labor used would determine potential man-hour costs per bale as a basis for accurately measuring labor utilization for the season. Daily margins between prices for cottonseed at the gin and available prices at nearby oil mills are needed to measure actual margins on cottonseed, ruling out gains or losses due to price change.

Integration of ginning with other operations. Intermittent operations of gins also suggests the possibility of integrating ginning, cottonseed oil milling, standard density compression, warehousing and storage, and the marketing of lint and other products all in a single cooperative enterprise. A preliminary study on a small scale of the possibilities of integrated operations is presently underway as a line project under general funds. Enlargement and expansion of the project is needed. Careful study and analysis of the economic possibilities of such an integrated enterprise is needed. An integrated operation of this kind by receiving cotton in the seed from farmers could operate around the clock for six or more months each year instead of intermittently for a period of 5 to 25 weeks as under existing practices. The significance of this situation is indicated by the fact there are enough gin plants in the United States to gin an average crop in 10 to 12 days if all available plants were operated to capacity. Other related facilities such as cottonseed oil mills and cotton compresses are excess to requirements if operated to capacity.

PRICE, SUPPLY AND CONSUMPTION ANALYSIS FOR FARM PRODUCTS (COTTON)

(BAE - A-2-7 - Federal-Regular Funds; BAE-RM-C-33 - Federal-State-RMA Funds)

(The discussion of line projects and expenditures on project RM-c-33 in this and other commodity chapters covers only work done by BAE. A general summary statement for this project, in Chapter 27, "Prices and Income" summarizes not only the research and expenditures of BAE but also shows expenditures of OES and lists OES line projects carried out through State and territorial experiment stations).

A. Purpose and Nature of Current Work

To (1) appraise the current and prospective economic position of cotton and rayon; (2) determine and measure the factors affecting prices, production, consumption and utilization of cotton and cotton products, including the influence of competition from related fibers; and (3) make the results of such appraisals and analyses available through regular publications and on special request to farmers, government agencies and the general public.

B. Currently Active Line Projects

A-2-7-10 - Price, supply and consumption analysis for cotton and rayon. To (1) appraise the current and prospective economic position of cotton and rayon; (2) carry on the statistical and analytical work necessary thereto, and (3) make the results available through regular publications and on special request. The Cotton Situation is prepared and issued under this line project.

RM:c-33.5A - Price, supply and consumption analysis for cotton and cotton products. To supply a basis for measuring the potential markets for cotton and cotton products and the most effective means of expanding these outlets. An additional objective is to measure the factors affecting the general level and structure of cotton prices. American cotton is facing increased competition from synthetic and other products in domestic and foreign markets. More knowledge of the effects of basic factors on market outlets for cotton and cotton products and prices is necessary to cope with these problems and there is also need for a better understanding of the significance of the supplies and comparative prices of synthetic fibers. In connection with the economic and statistical analyses involved in this project work there is also under way the preparation of a basic statistical handbook on cotton.

C. History and Evolution of this Work

(See this project in Chapter 27, "Prices and Income."

D. Funds -- Annual Expenditures

Expenditures by BAE from regular budget funds during the fiscal year 1950 amounted to about $15,300; expenditures by BAE from RMA funds amounted to approximately $6300.

E. Examples of Outstanding Accomplishments

A basic bulletin "Factors Affecting the Price of Cotton" was published in 1928. Numerous compilations of basic data on cotton and special analyses relating to the cotton problem have been prepared from time to time. A handbook of basic materials, "Cotton Statistics and Related Data for Agricultural Workers" was prepared in 1932, and a similar publication "Statistics on Cotton and Related Data" was prepared in December 1939 for use at the International Cotton meetings. During 1945 a large amount of analytic material relating to cotton was prepared for a series of documents developed by the Interdepartmental Technical Committee on Cotton. An example of this was Miscellaneous Publication No. 557, "Domestic Cotton Surplus Disposal Programs" published in September 1945. Similar material was also prepared for the "Study of Agricultural and Economic Problems of the Cotton Belt," a study requested by, and published in the hearings of the Special Subcommittee on Cotton of the Committee on Agriculture, House of Representatives, 80th Congress, 1st Session, July 1947.

F. Some Additional Work Needed

The analytic work on cotton needs to be extended to cover the demand for end-products containing cotton by household consumers and industrial users and it also needs to be extended to cover more thoroughly the competitive effects of other fibers. Research along these lines would strengthen the general outlook work for cotton and provide a firmer basis for long-time adjustment programs.

CONSUMER PREFERENCE RESEARCH (COTTON)

(BAE-A-2-25-Federal-Regular Funds; BAE-BHNHE-OES-RM-c-31-Federal-State-RMA Funds

(Related consumer preference research by BAE on other commodities is discussed in other commodity chapters. Consumer preference research conducted by BHNHE and OES, as well as line projects of BAE involving more than one commodity, are discussed in the general statement on consumer preference research in Chapter 26, "Economics of Marketing").

A. Purpose and Nature of Current Work

To obtain information about the attitudes and preferences of different groups of consumers toward cotton in items of clothing, household fabrics, industrial products in which cotton is used, and any other form in which cotton reaches a particular class of consumers. Through such research, to increase the domestic market for cotton, and improve the manufacture and merchandising of cotton products for the mutual benefit of cotton producers, marketing agencies, and consumers. Although consumer preference research on cotton was begun with regular appropriations for economic investigations, those funds were not adequate to meet the demands for research in this field. Allocations from Research and Marketing Act funds made it possible to meet, in part, the intensified demand from farmers' organizations and industry for such surveys on the possibilities of expanding outlets for cotton and cotton products.

B. Currently Active Line Projects

A-2-25-4 - Mothers' preferences among selected items of children's clothing To ascertain mothers' fiber preferences, dislikes and reasons for such attitudes among selected items of clothing for children 12 years old or younger; also, mothers' experiences with different fibers in the different garments.

A-2-25-5 - Women's fiber preferences among selected items of household textiles To discover fiber preferences, usages, and reasons for such preferences and usages in selected household fabrics among homemakers. Items covered are bedspreads, draperies, upholstery, curtains, slip covers, blankets, scatter rugs, and awnings.

RMA Funds:

RM:c-31.23 - Fabric and fiber patterns of use and preference among automobile manufacturers To explore the use of certain agriculturally produced textile fibers and their competitors in automobile upholstery and linings, to ascertain reasons for present practices, to obtain information on trends in the use of certain fabrics, and to discover what characteristics manufacturers want in fibers and what changes in present characteristics might lead to wider usage.

RM:c-31.24 - Fabric and fiber patterns of use and preference among tent and awning manufacturers To determine tent and awning manufacturers' present usages of fabrics, reasons for such usages, fiber preferences, desired characteristics of fabrics, relative costs, and related matters.

C. History and Evolution of This Work

The first of these consumer preference studies on cotton was begun in the fiscal year 1947. Using regular appropriations, research was undertaken on articles of women's clothing. This was followed with studies related to men's clothing, children's clothing, and household textiles that were financed with RMA funds. RMA funds are also being used to expand these studies to include the use of cotton in automobiles, awnings, and other industrial products.

D. Funds--Annual Expenditures

Consumer preference research on cotton undertaken by BAE during the fiscal year 1950 cost $91,000 from regular funds and $17,000 from RMA funds.

E. Examples of Outstanding Accomplishments

Improved merchandising of cotton and cotton products. Completed consumer preference research on cotton includes surveys on women's clothing and men's clothing. The National Cotton Council distributed results of the study of women's preferences among selected articles of clothing widely throughout the cotton trade by means of a brochure which it published, and a national magazine for women printed a detailed summary which it sent especially to department stores that deal in yard goods. The information was also widely used in advertising campaigns directed to distributors and consumers.

Supplied basis for improving cotton products. Research workers in the New Orleans regional research laboratory of the Department of Agriculture report that information already published as a result of these studies will furnish a valuable guide to future technological research on fiber characteristics. The results also supply a basis for reexamination of facilities, techniques and procedures in manufacturing, converting and fabricating cotton products.

F. Some additional Work Needed

Expansion to cover other groups of consumers. At present, the objectives covered are only a small part of those that bear on the problem so that further work will enlarge the scope of the information obtained. In many cases there is a need for the recurring collection of such information in order to establish time series of data. For example, the first and highly successful survey on Women's Preferences Among Selected Textile Products, if repeated as desired in 1951 (5 years after the original survey), would no doubt disclose significant differences which have developed in fiber preferences and in trends of use.

The study of institutional and industrial consumers needs to be expanded. For example, the survey of awning manufacturers ought to be supplemented by studies among architects and builders, especially of factory, office, hotel, and similar structures for it is often at this point that the decision about what type, if any, awnings to be used is made. Studies among the manufacturers of rope and cordage are highly desirable in the near future. Cotton in the manufacture of insulated electric wire is coming into increasingly greater competition with other insulating materials and a study among these industrial consumers should prove useful.

In fact, there are many industries using cotton in their products where this fiber is in heavier competition with other materials than was formerly the case. Such consumers need to be studied to find out why they may be decreasing their use of cotton and what can be done to restore it to favor.

MEASUREMENT OF COSTS AND MARGINS IN MARKETING FARM PRODUCTS--(TEXTILES)
(BAE - RM-c-163-5 and 6 - Federal - RMA Funds)

(Related work in this project is discussed in other commodity chapters and in Chapter 26, "Economics of Marketing")

A. Purpose and Nature of Current Work

To (1) measure costs and margins in marketing cotton and wool and their products, (2) indicate the influence of factors affecting these costs and margins, and (3) indicate means of increasing the efficiency and of reducing the costs of marketing these products.

B. Currently Active Line Projects

RM:c-163.5 - Measurement and analysis of changes in margins and costs for marketing textile products.

To assemble information to show periodically margins and costs for cotton and wool and their products at each important stage in the marketing procedure, to indicate the relation of changes in these margins and costs to changes in prices and in other factors, and to indicate means of bringing about needed adjustments.

RM:c-163.6 - Analysis of efficiency and costs of manufacturing carded cotton yarns.

To assemble and analyze information to show what appears to be the most promising areas and the most feasible means of reducing costs of manufacturing carded cotton yarns.

C. History and Evolution of This Work

The Department was directed to make studies of this general type by the Research and Marketing Act of 1946, and these lines of work were approved by the Cotton Advisory Committee fairly early in the development of the RMA program.

D. Funds--Annual Expenditures

The costs of these RMA projects on costs and margins in marketing textiles undertaken by BAE totalled $4,400 during the fiscal year ending June 1948, $62,400 for the fiscal year 1949 including a contract, and $17,800 for the fiscal year 1950.

E. Examples of Outstanding Accomplishments

Information relating to changes in margins for textiles show that the proportions of net sales accounted for by gross margins of wholesalers and of retailers of textile products increased during the early 1940's, but in the postwar period they have decreased, and by 1948 were approximately equal to those in 1939.

The results of studies of the efficiency and costs of manufacturing carded cotton yarns now being prepared for publication show how substantial reductions in these costs could be made by the use of improved machinery and by adjustments in organization of plants and in workloads for machinery and labor.

F. Some Additional Work Needed

Further research is needed to keep data on costs and margins up to date and to show the relations of these costs and margins to changes in prices and in other factors and to indicate feasible means of bringing about desirable adjustments. Studies of efficiency and costs similar to that completed for manufacturers of carded cotton yarns need to be expanded to other segments of the cotton and wool textile industries.

REGIONAL MARKETING OF COTTON (INCLUDING COTTONSEED)

(BAE, PMA, FCA, BPISAE - RM-b-228 - Federal-State - RMA Funds)
(Conducted in cooperation with the States on Regional Project SM.1 - See Chapter 39.)

A. Purpose and Nature of Current Work

To strengthen the competitive position and expand the outlets for American cotton through adjustments in quality to market requirements and improvements in marketing efficiency which will reduce costs, and provide a closer correspondence between prices, the quality of the cotton produced, and the market value of the products. Information on qualities of cotton best suited to their needs is being obtained from mills, and marketing agencies are being studied to find out about the marketing methods and channels used and services rendered in connection with the handling of raw cotton. All the work done under this project is in close cooperation with the Agricultural Experiment Stations of several of the cotton growing States.

B. Currently Active Line Projects

RM:b-228.2 - Marketing of one-variety community cotton. To assemble information that will show the extent of the differences between one-variety and other comparable areas in quality or spinning value of the cotton produced; in costs of production; and in marketing facilities, methods, practices, and costs. This information is intended to show what changes are needed to improve marketing methods, practices, and costs and to realize more fully the benefits of one-variety area production.

RM:b-228.3 - The buying practices and demands of mills using raw cotton. To secure information from mills which can be used as a basis for recommending adjustments in the cotton-marketing system so as to supply mills with the qualities of cotton best suited to their individual requirements, and to provide for the movement of cotton from farms to mills in the most efficient manner. Results should ultimately benefit cotton farmers as well as cotton mills.

RM:b-228.4 - Efficiency and costs of marketing cotton. To develop information regarding the relative efficiency of the major marketing channels as a basis for recommendations to increase the efficiency of the cotton-marketing system through improvements in the services offered and reductions in the costs of the marketing processes. These studies will supplement work being done under Department projects relating to both the measurement of costs and margins for cotton and products all the way from producer to consumer, and the analysis of factors affecting cost and efficiency in carded cotton mills which is being conducted under contract.

C. History and Evolution of This Work

Agronomic work by the Department on the one-variety idea dates back several decades. Marketing problems similar to those covered by this project also received some attention in those years with the Department conducting research in certain phases of the field on an irregular basis since about 1927. Work under the present work project was started on an experimental basis in 1948. During that year the research was confined mainly to the marketing of one-variety community cotton as contrasted with the usual marketing of cotton in comparable community areas. In 1949 research relating to the marketing of one-variety community cotton was expanded to a belt-wide basis, and studies relating to the buying practices and demands of mills using raw cotton were begun. During 1950 studies relating to the marketing of one-variety community cotton were mostly completed. Progress was made on studies relating to the buying practices and demands of mills using raw cotton, and research relating to the efficiency and costs of marketing cotton on a belt-wide basis was started, the areas covered including both one-variety and other communities.

D. Funds--Annual Expenditures

Funds spent on this project by Department agencies through the end of June, 1950 are:

	Fiscal year 1948	Fiscal year 1949	Fiscal year 1950
BAE	$ 2,500	$ 7,500	$ 9,800
PMA	5,200	3,800	4,700
FCA	300	0	0
BPISAE	400	700	0
TOTAL	$ 8,400	$12,000	$14,500

E. Examples of Outstanding Accomplishments

Disclosure of fact that many of the areas designated as one-variety are not truly one-variety areas and the marketing methods and practices in some of them are essentially the same as those in other adjacent areas. Among other discoveries: In truly one-variety community areas, the cotton was found to be more uniform in quality and some of the marketing methods and practices were better than in adjacent areas, but considerable improvements are needed before producers in one-variety areas can hope to realize the full benefits of one-variety production.

Disclosure of qualities of cotton used in the manufacture of specific kinds of fabrics, the sources from which this cotton was obtained, and the buying practices of mills. This information will be useful as a basis for indicating the adjustments that must be made if mills are to be supplied with the kind of cotton relatively best adapted to the manufacture of specific kinds of products they make.

F. Some Additional Research Needed

Additional research relating to buying practices and demands of mills would disclose the influences of various factors in determining the qualities of cotton relatively best suited to the production of specific products, the areas relatively best suited to the production of this cotton, and changes the marketing methods and practices needed in order to most economically provide mills with the kind of cotton that will most advantageously meet their needs. These findings will be of direct value to producers in indicating market trends and prospective income from the varieties of cotton most suitable for different areas.

More intensive studies on marketing phases. Studies relating to the efficiency and costs of marketing cotton have been concerned mainly with the channels, services, and charges for marketing. This information supplies the background for more intensive studies of specific channels, agencies, and services, to serve as a basis for indicating changes to increase efficiency and reduce costs.

MARKETING METHODS AND DISTRIBUTION FOR COTTON AND COTTONSEED
(PMA - Federal - Marketing Farm Products Funds)

The various phases of the work under this project have the common objective of developing improved marketing methods, facilities and procedures for the marketing of cotton and cottonseed. The variety and extent of the work on these commodities has made it advisable to organize and conduct the various phases under sub-projects as follows:

1. Developing improved practices, facilities and procedures for the marketing of raw cotton.
2. Marketing practices of cotton mills in procuring cotton of qualities needed in relation to qualities produced by crop-improvement groups.
3. Improved technology for ginning and associated processes in the preparation of cotton and cottonseed for market.
4. Economic aspects of commercial cotton ginning operations in the preparation of cotton and cottonseed for market.
5. Developing improved practices, facilities and procedures for the marketing of cottonseed.

DEVELOPING IMPROVED PRACTICES, FACILITIES AND PROCEDURES FOR THE MARKETING OF RAW COTTON
(PMA - Federal - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

To reduce the costs of marketing cotton and provide more equitable returns to growers by developing factual information necessary for evaluating the marketing system for raw cotton in all its stages from farms to cotton mills. Emphasis is directed at improving procedures and practices in marketing and incidental services such as sampling, classification, weighing, marking, storage, compression and transportation with a view to increasing the efficiency of the marketing system. Particular attention is given to the possibilities of improving trading conditions and facilities at markets where growers sell cotton.

B. Currently Active Phases of This Work

Determining costs and practices of preparing cotton for market and for physical handling in marketing channels. To ascertain the actual charges paid by growers for ginning and packaging cotton in all sections of the Cotton Belt and to develop information from season to season relative to charges made for the storage, receiving, and compression of cotton by public storage agencies, in order to measure the efficiency of such services and the factors influencing the level of charges.

Developing improved methods of sampling cotton bales and their coordination with marketing procedures. To develop a method of sampling cotton bales at gins, by automatic mechanical means that will provide a truly representative sample of the bale contents without requiring mutilation of the bale covering and subsequent loss or damage to exposed cotton and to devise means to coordinate such an improved sampling technique with marketing procedures in order to use the sampler on a commercial scale.

Appraising procedures, practices, and pricing methods utilized in the marketing of cotton at major spot markets. This study is designed to appraise the use of government classification in trading at the major spot markets and to aid in the selection of the most logical markets for the purpose of collecting and distributing detailed and accurate market news information to farmers, under the provisions of the U. S. Cotton Futures Act. Another objective is to ascertain the possibilities and advantages of increasing the volume of direct trading between producers and marketing agencies located at major spot markets with a view to reducing marketing costs.

C. History and Evolution of This Work

Although some studies of practices in the marketing of cotton had been conducted by the U. S. Department of Agriculture previously, work under this project was initiated during the 1932 fiscal year. The work initiated at that time was limited to research on such chronic problems of cotton marketing as tare practices and weights used in marketing transactions. The work was later broadened to include studies of lines of movement of cotton between producers and spinners markets, problems and costs of physical handling of cotton in marketing channels, price-quality relationships in producers local markets and cost of preparation of cotton for market. In 1935 the first Belt-wide study of marketing practices in producers local markets was conducted. This study indicated the need for public services to provide cotton producers with impartial information with respect to the quality and market value of their product to improve their bargaining positions in marketing. With the enactment of the Smith-Doxey Act in 1937 to provide classification and market news services to cotton producers organized for cotton quality improvement, the emphasis in marketing research was concentrated on such technical problems of marketing cottons as sampling and identification of cotton bales. Beginning in 1944 a series of studies of marketing practices and problems in the central spot markets were initiated.

D. Funds - Annual Expenditures

1950 fiscal year approximately $35,000. Expenditures have ranged from $10,000 to $35,000 per year during the period 1931 to 1949.

E. Examples of Outstanding Accomplishments

Development of an automatic mechanical device for sampling cotton bales has been accomplished entirely through research in the Department. This sampling machine consists of several units of related apparatus which collect, assemble, press, and package a truly representative sample without mutilating the bale covering. Public service patents have been granted on original features of this device.

Designing a permanent identification tag for cotton bales. A metal tag attached to a steel wire anchor inserted in the ginned lint before the bale is pressed and tied has been developed and patented. This tag preserves pertinent information as to the origin, number and year of growth of the bale. It is also corrosion- and fire-resistant.

Maintenance of an extended series of data relating to charges for ginning and packaging cotton and the physical handling of bales in marketing channels. Information relative to charges paid by growers for ginning and packaging cotton has been assembled and compiled seasonally since 1928. Records of charges assessed for storing, receiving, sampling and compressing cotton likewise have been maintained since 1932. Such data have prompted study of the various factors influencing the level of such charges and aided in determining total costs involved in producing and marketing cotton.

Studies of marketing practices in producers' local markets. In 1935 and again in 1947 studies were conducted at typical producers' markets providing detailed information on the practices of growers in selling cotton, their use of governmental marketing aids, the facilities available in such markets and the procedures of first-buyers used in reselling the cotton. These have been the only such Belt-wide studies and have provided essential background information for planning improvements in local market facilities and practices as well as appraising the effectiveness of governmental marketing services. Findings have highlighted the nature and extent of undesirable practices that require correction to improve the bargaining position of cotton farmers.

Studies of the packaging of raw cotton. Through extensive experimentation several means of eliminating undesirable features in the packaging of cotton were definitely established. Tests indicated that standardization of wrapping materials and subsequent net-weight trading in cotton were entirely feasible. Lighter weight materials for wrapping and tieing bales were found to be suitable.

F. Some Additional Work Needed

Improvement of trading practices at producers' local markets. Detailed case studies of selected producers' markets where improvements in procedures have been outstanding are highly desirable for use in providing growers elsewhere with a guide for possible correction of undesirable features of local market operation.

Development of a more effective market news service. A study should be made of possibilities for expanding the use of market news service for cotton and of providing more timely quotations for a wide range of qualities at a greater number of representative spot markets. This would make available price and other market information for use by producers along with the official classing service, and thereby improve the bargaining status of growers.

Appraisal of possibilities for increasing the volume of trading at producers' markets. Many markets receive too small a volume of sales to attract more than one buyer. Such markets are not highly competitive, cannot support proper facilities, and increase marketing costs unnecessarily. Studies are desirable for devising means of eliminating many such markets and concentrating trading at strategic locations.

~~Expansion of government classing service. Means should be devised for increasing the acceptance of the official classification by marketing agencies in marketing transactions with growers.~~

MARKETING PRACTICES OF COTTON MILLS IN PROCURING COTTON OF QUALITIES NEEDED IN RELATION TO QUALITIES PRODUCED BY CROP IMPROVEMENT GROUPS

(PMA - Federal - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

(1) To ascertain the practices of cotton mills in procuring cotton of the qualities desired for specific uses, (2) to evaluate the fiber characteristics and spinning performance of cotton produced each year in various areas throughout the Cotton Belt by crop improvement groups, and (3) to develop more effective practices for marketing cotton produced by crop improvement groups and provide better market outlets for such cotton.

The current work is particularly concerned with aiding cotton producer groups in finding better markets and wider outlets for their improved varieties and with assisting cotton merchants and mills in locating cotton of improved varieties in even running lots as required.

This work differs from but is closely related to work being conducted under Project RM-c-70 entitled "Improving Market Outlets for Various Kinds of Cotton in Relation to Merchandising Procedures." Work under that project is directed specifically to an evaluation of the qualities of cotton actually being used for and those best suited to the manufacture of each of the principal products made from cotton. The results of that work, when analysed in relation to information on qualities of cotton being produced as developed in connection with this project, will provide a basis for indicating the relation of qualities of cotton being produced to those required by cotton mills.

B. Currently Active Phases of This Work

Textile mill practices and preferences in the procurement of raw cotton of types and qualities required for the manufacture of specific products. To ascertain the practices and preferences of cotton manufacturers in the procurement of cotton for various uses and to ascertain the possibilities for improvements in marketing cotton from crop improvement areas.

Determination of fiber and spinning qualities of pure variety cottons produced annually in cotton improvement areas. To determine by means of laboratory fiber and spinning tests the fiber and spinning quality of pure varieties of cotton produced annually by cotton improvement

Page 146, delete the second paragraph and substitute the following copy:

Integration of official classification of cotton with marketing procedures. Means should be devised for improving and increasing the acceptance by marketing agencies of official classification of cotton.

ERRATA TO REPORT ON RESEARCH, SERVICE, AND MARKETING EDUCATIONAL WOR
IN THE UNITED STATES DEPARTMENT OF AGRICULTURE

On the printed copies of this report the title will appear as "Repor
Research and Related Services in the United States Department of Agr
ture". It is also pointed out that the following errata do not inclu
a considerable number of minor corrections and editorial adjustments
which have been made in the manuscript submitted to the House Committ

groups, to facilitate the procurement by mills and merchants of cotton of the qualities desired, and to aid producers of cotton of desirable spinning quality in establishing market outlets for their product.

C. History and Evolution of This Work

During the past two decades or more considerable progress has been made by cotton breeders in developing improved varieties and strains of cotton, adaptable to the different geographical conditions in the Cotton Belt and having improved spinning value. Along with this development, growers in producing areas such as a county, several counties, or even larger areas have been induced to standardize their production by limiting it to a single variety of cotton, the variety having been selected as being the best for that particular area. In order that producers and spinners may profit most from these developments, information was needed on textile mill practices in the procurement of cotton of desired qualities and also better dissemination was needed of information on fiber and spinning qualities of the cotton produced annually in cotton improvement areas in order to assist cotton merchants and spinners in locating cotton of the qualities desired, and aid producers of desirable types of cotton in developing the most profitable market outlets for their product.

The portion of this work related to textile mill practices in the procurement of raw cotton of types and qualities desired, based on surveys of cotton mills, has been re-oriented to a considerable degree subsequent to its initiation during the 1946 fiscal year. With the results of the first phase published in 1947, the study is now designed to provide information with respect to the extent to which textile mills are effectively modifying their procurement practices as a result of the development of more precise methods for the evaluation of the various cotton quality factors.

Formerly, cotton variety spinning tests were limited to cotton from breeder's blocks or from experiment station plots. One phase of this study provides current information on the various quality characteristics of varieties actually being grown under commercial conditions; and also timely reports whereby merchants and manufacturers can locate areas from which cotton of desired quality may be obtained. This works to the benefit of cotton breeders, farmers, merchants, and manufacturers. These test results, which are published currently, have gained in usefulness and popularity each season. They are now an established source of information with respect to the fiber characterustucs and spinning performance of cotton in each annual crop, depended on by breeders, merchants, and manufacturers to an increasing extent each year.

D. Funds - Annual Expenditures

1950 fiscal year, approximately $45,000. Expenditures have ranged from $20,000 for the 1946 fiscal year when the project was organized to $40,000 for the 1949 fiscal year.

E. Examples of Outstanding Accomplishments

Establishment of series of reports on fiber characteristics and spinning performance of cotton produced in standardized variety areas throughout Cotton Belt. Annual studies of the fiber characteristics and performance in spinning of the leading varieties and strains of cotton being produced commercially in crop improvement areas throughout the Cotton Belt, which were initiated during the 1946 cotton season, have provided the basis for a series of current reports on the spinning quality of each cotton crop. The results of fiber and spinning tests on cotton from approximately 100 selected areas are published currently as each crop is harvested and tested. The usefulness of this series of reports to farmers, cotton merchants and textile manufacturers has become widely recognized.

Development of information concerning mill practices in the procurement of raw cotton of types and qualities required for specific uses. Information developed from a comprehensive study of mill practices in the procurement of raw cotton for specific types of products provide a basing point from which to measure changes in mill procurement practices that are now taking place as a result of the development of methods for the more precise evaluation of raw cotton quality. This information will also provide a basis for adapting marketing procedures to provide for more effective marketing of cotton produced in standardized variety areas.

F. Some Additional Work Needed

Development of more effective methods of marketing and better market outlets for cotton produced by crop improvement groups is needed in order to enable cotton producers and cotton manufacturers to realize the full advantages accruing from this system of cotton production.

The annual quality studies of varieties in commercial production in various cotton improvement areas should be continued. Provision should be made for testing an increased number of varieties and strains and for a wider coverage of producing areas in order to aid cotton producers in establishing advantageous market outlets for their product and to assist cotton merchants and textile manufacturers in locating sources of cotton of the spinning qualities desired.

IMPROVED TECHNOLOGY FOR GINNING AND ASSOCIATED PROCESSES IN THE PREPARATION OF COTTON AND COTTONSEED FOR MARKET

(PMA Federal Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

To develop improved facilities and methods for conditioning, cleaning, ginning and packaging of cotton and to determine the comparative effectiveness of various available types of ginning and auxiliary equipment currently available to the industry. This work is particularly concerned with the best operating conditions and methods to preserve the inherent qualities of the improved types of cotton now being produced in this country, to increase the returns to cotton growers and improve the competitive position of cotton in general. The project is being conducted cooperatively with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

30.7

Work under this project differs from that being conducted in Projects RM-a-71 and RM-c-71 in that this work is limited to research designed to improve basic ginning and associated processes, whereas Project RM-c-71 is confined to such special items as the conditioning and storage of mechanically harvested seed cotton prior to ginning, special problems of ginning peculiar to specific cotton-producing areas, the conditioning of cottonseed at gins, the development of new principles of cleaning cotton at gins, and other special problems of ginning associated with changing practices in the production and harvesting of cotton.

B. Currently Active Phases of This Work

Determining and attaining optimum moisture content of cotton for various gin processes. This work has as its objective the determination of optimum moisture content for ginning and the various associated processes in order to obtain the most efficient and effective use of the various machines and optimum quality of the ginned products.

Gin stand research--improved moting. The objective of this work is to evaluate fully a device which has been developed in an attempt to give improved moting and cleaning within the gin stand. The device consists of reciprocating grid bars installed behind the saw cylinder. Preliminary tests have shown that it offers promise but needs exhaustive tests and comparison with other methods of cleaning.

Seed cotton cleaning--green boll removal. A device has been developed to trap and remove unopened bolls from the seed cotton as it is being handled pneumatically at the gin. The objective of this work is to determine the effectiveness of this device under full-scale operating conditions and the resulting effect on the quality of the ginned lint and seed and whether or not there are any possibilities for reclaiming usable products from the bolls so removed.

Seed cotton cleaning--stick removal. The objective of this work is to develop attachments for existing extracting and cleaning machinery for seed cotton which will improve their efficiency through the removal of sticks and stems, which comprise a heavy proportion of the foreign matter in hand-snapped and machine-stripped cottons. Early tests indicate that the efficiency of the machines can be improved through use of a device which has been developed, and further tests should be conducted to determine its effectiveness on seed cotton handling machines operating singly or in conjunction with other units.

C. History and Evolution of This Work

This project was initiated in 1931 with the establishment of the U.S. Cotton Ginning Laboratory at Stoneville, Mississippi. It is now operated cooperatively by the Cotton Branch of PMA, and BPISAE of ARA. Early work was concentrated on the most efficient use of cleaning and ginning machinery then available on the market and the development of improved handling and ginning methods. This was accompanied by research work into harvesting practices in order to insure that the seed cotton would reach the gin in as favorable condition as possible with regard to moisture and foreign matter content. The staff of the laboratory has worked continuously with gin machinery manufacturers and ginners in the industry to apply the findings of the laboratory to actual practice in the development of new equipment and practical operating conditions.

D. Funds--Annual Expenditures

1950 fiscal year approximately $60,000. Expenditures have ranged from about $35,000 for the 1931 fiscal year to $60,000 during the 1949 fiscal year.

E. Examples of Outstanding Accomplishments

1. The vertical drier for seed cotton. Equipment and procedures for drying seed cotton were developed at the U. S. Cotton Ginning Laboratory and thoroughly tested during the early 1930's. Patents were granted and dedicated to the public which have been widely used since in handling each annual cotton crop. Proper operating conditions and temperatures were established for the various conditions in which seed cotton reaches the gin and considerable education of ginners has been accomplished both by the laboratory staff and the Extension Service in the use of this equipment. In 1935 there were only about 200 gins in the country using driers and this figure has increased until approximately 5,000 out of the 8,000 active gins will be using this process for the 1950 crop.

2. ~~Standard density presses. It has long been recognized that present methods of packaging cotton are wasteful and inefficient. The present practice is to bale the lint cotton at the gin at "low density" (about 12 lbs. per cu. ft.), ship to a compress where it is re-pressed to "standard density" (22 lbs.) for domestic shipment or to "high density" (32 lbs.) for export. Experimental presses have been developed at the Laboratory which produce economically "standard density" bales at the gin. This practice reduces the space needed for storage, and reduces aggregate costs of packaging and handling in marketing channels.~~

3. Lint cleaner. The grade of cotton lint is largely determined by the amount of fine trash which it contains. Logically the best place to remove this "pepper trash" from the cotton is immediately after the gin saws release it, since never again will the lint be as light, fluffy and buoyant. After many trials and long years of basic research a new type of cleaner was designed for installation just behind the gin stand, called a "lint-flue cleaner." More than 500 cleaners, based on the Laboratory's work, where in commercial use in 1949. They increased the grade of the cotton from 1/3 to 1/2 grade without damage to its spinning qualities. From 1200 to 1500 lint cleaners will be in use in the 1950 cotton season.

4. Proper gin stand operation. One of the primary problems of a ginner is capacity of gin stands. Much work has been done at the laboratory to improve capacity without detrimental effects to the quality of the lint and seed. Studies were made to determine the most efficient size and type of gin saw teeth as well as the speeds at which gin saws could be operated. It was found that the harmful practice of "tight-roll ginning" which was being used to increase capacity could

Page 150, delete the paragraph under the heading "Standard-density presses", and insert the following:

Standard-density presses. It has long been recognized that present methods of packaging cotton are inefficient and wasteful. The present practice is to package lint cotton at the gin in bales of low density (about 12 pounds per cubic foot), ship the bales to a compress where they are repressed to a standard density (about 22 pounds) for domestic shipment or to high density (about 32 pounds) for export. A gin press which produces "standard density" bales suitable for all domestic shipments was developed and thoroughly tested at the Ginning Laboratory. Complete details with respect to this development have been published. In the meantime, presses of this type have been installed at several commercial gins where both the economic and mechanical feasibility of gin standard density compression have been demonstrated under commercial ginning and marketing conditions. An important feature of gin standard density compression is the bale package thus afforded, which is superior from the standpoint of uniformity in bale shape and dimensions as well as protection of the bale contents.

on Agriculture as printer's copy.

Chapter 1, pages 1 and 2, the word "Landranee", wherever it appears, should be "Landrace".

Chapter 3, page 87, item D, the amount of funds should be $34,500, not $17,500.

Chapter 5, page 55, tenth line, change "reorganized" to "recognized".

Chapter 10, page 1, first line of first line project should read "Breeding for" instead of "Breeding and".

Page 95, under item D, the amount of funds should be, respectively, $302,000, $179,000, and $228,000 instead of $113,000, $94,600, and $150,700.

Page 123, substitute the following copy for second and third full paragraphs:

Standard density presses. It has long been recognized that present methods of packaging cotton are inefficient and wasteful. The present practice is to package lint cotton

530.7

be corrected by increasing the saw speeds. Now practically all modern gins operate at speeds well above those in the past and are able to attain satisfactory capacity without harmful effect on the fiber.

F. Some Additional Work Needed

Further research is needed to establish the optimum moisture content for cleaning seed cotton as well as the best conditions for ginning and pressing. Previous tests have shown that dry cottons clean better but they are sometimes too dry for the best ginning and pressing conditions. Practical means of automatically regulating moisture removal and restoration need to be developed in order to correct these difficulties.

Additional gin stand improvement. Further improvement in the gin stands and auxiliary equipment are no doubt possible to assure more efficient operation, improved quality of product and lower operating costs. Additional investigations are needed to determine the possibilities of such improvements either through redesign of equipment, or the addition of accessories which are proved to be beneficial.

ECONOMIC ASPECTS OF COMMERCIAL COTTON GINNING OPERATIONS IN THE PREPARATION OF COTTON AND COTTONSEED FOR MARKET

(PMA - Federal - State - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

Studies of the economic aspects of ginning were designed to provide information with respect to the costs and efficiency of ginning services performed by commercial ginning establishments employing various types and combinations of ginning equipment and operating under various conditions throughout the cotton-producing areas of the United States. Specific objectives are to determine: (1) Comparative costs and quality of ginning services performed by gins employing different types of equipment, (2) comparative returns to cotton producers resulting from obtaining ginning services where different types and combinations of gin equipment are employed, and (3) the effect of volume on costs of performing ginning services under various conditions prevailing in specific cotton-producing areas.

Since there are wide variations in the factors affecting gin operations in different cotton-producing areas because of differences in types of cotton produced, climatic conditions and harvesting practices, it is necessary that these studies, to have definite meaning, be made on an area basis. Areas selected for study are delineated in each instance to provide relatively uniform conditions with respect to types of cotton produced and conditions of gin operation. Representative gins are selected in each area as a basis for the detailed studies. This work differs from work being conducted under Project RM-a and c-71 and other research and ginning being conducted with regular funds in that this project relates strictly to commercial ginning operations whereas the work under the other projects consists primarily of technological development work designed to provide an improved technology for ginning and associated processes.

B. Currently Active Phases of This Work

Evaluation of the cost and quality of ginning services being performed by commercial ginning establishments in the High Plains area of Texas. This study is designed to provide information with respect to the economic and technological factors affecting the quality of ginning services under the wide range of harvesting conditions prevailing in the area. These harvesting practices include hand snapping and machine stripping as well as a limited amount of hand picking. The work is designed to indicate to cotton ginners and producers the most advantageous type of ginning service from the standpoint of cost of such service and returns from lint and seed.

Evaluation of cost and quality of ginning services being performed by commercial ginning establishments operating in the Yazoo-Mississippi Delta. The objective of this work is to determine (1) the factors affecting the quality of ginning in the area with installations of ginning equipment employing varying amounts and types of cleaning and conditioning equipment; (2) the comparative returns to producers from ginning cotton at various types of gin establishments; (3) the comparative costs of operation of gins of various sizes employing different types and amounts of cleaning and conditioning equipment and having varying volumes of ginning, and (4) the volumes essential for the financial success of these establishments.

Cost and quality of ginning services performed by commercial ginning establishments operating in South Louisiana. The purpose of the study is to ascertain (1) the factors affecting the quality of ginning services under the conditions prevailing in the area, (2) the comparative costs of operation for gins variously equipped and having different volumes of ginning, and (3) the volumes of ginning required for ginners to provide a service that will also be of financial benefit to producers.

Evaluation of cost and quality of ginning in the Piedmont area of Georgia. Problems common to the Piedmont area of the Southeast are being analyzed on the basis of a detailed study of representative gins in the Piedmont area of Georgia. This study is expected to reveal the quality of ginning provided by plants equipped with varying amounts of cleaning and drying equipment for handling hand-harvested cotton, the cost of providing ginning services at gins equipped with different amounts of cleaning and drying machinery, and the factors affecting efficiency of operation.

C. History and Evolution of This Work

Analyses of ginning costs and quality of ginning as related to financial returns to cotton growers, the first of the studies coming under the area of work covered by this project, were begun in 1944 in five adjacent counties of central Mississippi. This was followed by a similar study in 1945 including the same counties and four additional counties in northeastern Mississippi. It was immediately apparent that sampling and analysis of seed cotton brought to the various types of gins would need to be done if the full aims of the study were to be realized. Subsequent studies have, therefore, included sampling of seed cotton and lint at the selected gins in order to determine the condition of the cotton that arrived at the various types of gins as well as the

530.7

quality of ginning services as reflected by lint quality. In both economic and technological aspects the present staff assigned to this project has gained valuable experience that will facilitate the analysis of similar problems that may arise in other areas throughout the Cotton Belt.

D. Funds--Annual Expenditures

1950 fiscal year approximately $30,000. Expenditures have ranged from about $10,000 during the 1945 fiscal year to $30,000 during the 1949 fiscal year.

E. Examples of Outstanding Accomplishments

Detailed studies of costs and quality of ginning services in a number of areas in the Cotton Belt, have indicated the comparative costs and quality of ginning services performed by gins employing different types of equipment. These findings have enabled gin owners to utilize their resources more effectively in providing better ginning.

Comparative returns to cotton producers resulting from ginning services where different types and combinations of gin equipment are employed have been determined. For instance, on the High Plains of Texas where elaborate cleaning systems have been found necessary to process effectively the roughly harvested cotton, the cost of ginning at elaborately equipped gins is about $1 per bale higher than for gins operating with more limited cleaning equipment, while the elaborately equipped gins turned out cotton averaging approximately $3 per bale higher in value than that at plants with less elaborate cleaning equipment.

Determination of factors responsible for unsatisfactory quality of ginning services in South Louisiana. In the study in this area it was found that the principal factors responsible for poor quality ginning were lack of proper drying and cleaning equipment combined with practices of cotton growers of delivering cotton of high moisture and trash content to the gins. It was found, too, that the returns to growers would be increased sufficiently, by the installation and proper use of such equipment, to more than compensate for the extra cost.

F. Some Additional Work Needed

Because of the trend toward harvesting of cotton by methods other than hand-picking, and the constant changes in types of ginning machinery and ginning techniques, these studies should be continued in some of the areas already studied and extended to other areas where conditions differ from those in areas already studied. Particular attention should be given to methods of gin operation, including saw speed, density of seed roll, general condition of operating machinery, type of power used, and management and use of labor. Analysis should also be made of moisture content and general condition of seed cotton delivered to the gins and the comparative value of lint turned out by the gins with a view to enabling ginners to select the best type of gin equipment for their particular locality and to provide growers a service that will enable them to take to market cotton of the highest possible quality.

DEVELOPING IMPROVED PRACTICES FACILITIES AND PROCEDURES FOR THE MARKETING OF COTTONSEED
(PMA - Federal - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

To provide an evaluation of practices, costs and facilities in the marketing of cottonseed with a view to improving the efficiency of marketing and reducing costs. The basic data for evaluations of marketing practices are being developed from systematic surveys throughout the Cotton Belt, supplemented by intensive area studies of the functioning of the price system and other specific problems of marketing this product. Technological problems of marketing, such as sampling for quality evaluations and weighing as a basis for marketing transactions, involve laboratory developmental work.

B. Currently Active Phases of This Work

Cottonseed marketing practices, costs and facilities. To develop information with respect to and provide an evaluation of practices, costs and facilities for marketing cottonseed in various cotton-producing areas throughout the Cotton Belt.

Cottonseed prices and price-quality relationships. The study includes an evaluation of methods of cottonseed price dessemination with a view to providing more adequate and more timely market information for the guidance of farmers, ginners, and crushers. Analyses of cottonseed price-quality relationships to indicate the extent to which prices to producers reflect milling value is an important phase of this work.

C. History and Evolution of This Work

The first Belt-wide study made of cottonseed marketing practices, costs and facilities was initiated during the 1947-48 cotton season. This had been preceded by a pilot study in a limited area made during the 1946-47 cotton season. A pilot study of cottonseed prices and price dissemination was initiated in a limited area during the 1949-50 cotton season. This study was designed to develop and test suitable methodology for research in this field as a basis for more extensive studies throughout the Cotton Belt.

D. Funds--Annual Expenditures

1950 fiscal year approximately $17,000. Expenditures have averaged about $15,000 per year since the project was organized during the 1948 fiscal year.

E. Examples of Outstanding Accomplishments

Since work in this field was only recently initiated, there has been only limited opportunity for significant accomplishments in the way of improvements in the marketing of cottonseed. The report of the results of the first Belt-wide study of the marketing of this commodity, which was published in 1949 under the title "The Marketing of Cottonseed," has had

30.7

relatively wide distribution and has received considerable commendation for its value to the industry. The findings of this study indicate that the present basic weaknesses in the marketing system for raw cottonseed are the use of estimated weights in sales of cottonseed by farmers and the failure to take quality into consideration in grower-first buyer transactions. The attention of the industry has been focused on these specific problems and it can be anticipated that ultimately they will be solved.

F. Some Additional Work Needed

Development of automatic mechanical sampling of cottonseed during ginning. With the prospective early development of a simplified system of grading of cottonseed at gins as a basis for sale by growers, there will be need for a satisfactory system of obtaining a sample from each lot of seed for use in grading. Because of the variability in seed quality within each lot, the problem of obtaining a representative sample upon which to base the grade would be simplified by the development of automatic mechanical means for accumulating a proportionate sample throughout the ginning of the bale.

Development of a more satisfactory system of weighing cottonseed at gins. Approximately 2/3 of the sales of cottonseed by farmers are based on estimated weights. Scales designed for weighing cottonseed have not been considered entirely satisfactory because of the problem of separating the seed lots for individual bales ginned. There is need for finding a solution to this problem.

DEVELOPMENT OF GRADES AND STANDARDS FOR COTTON AND COTTONSEED
(PMA - Federal - Marketing Farm Products Funds)

Work under this project is designed to provide a scientific basis for the official standards of quality for cotton and cottonseed, to relate such standards to the use value of these commodities and to provide means and methods for improving the accuracy and facility with which the standards can be applied in making quality evaluations for purposes of marketing transactions. The scope and extent of the work has made it advisable to organize and conduct the various phases under sub-projects as follows:

1. Development of improved standards of quality for cotton.
2. Improved standards of quality and methods of grading cottonseed.
3. Relationship of cotton fiber properties and other factors of quality in raw cotton to processing performance and quality of manufactured products.
4. Development of improved equipment and techniques for cotton fiber and spinning testing.

DEVELOPMENT OF IMPROVED STANDARDS OF QUALITY FOR COTTON
(PMA - Federal - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

Standards for grade and staple length of cotton as established in physical and descriptive form under the Cotton Standards Act are used in most marketing transactions in American cotton throughout the World. In order to assure accurate graduations in the standards and their satisfactory reproduction, scientific instruments and techniques are being developed and applied for measuring the various factors of quality represented in the standards and in associated fiber qualities. Such work is designed to provide improvements in the standards, the development of standards or measurement techniques for qualities not now represented by physical standards, and the development of standardized facilities or methods that will make it easier to apply the cotton standards with precision, thus benefiting all phases of the cotton industry from farmer to consumer.

B. Currently Active Phases of This Work

Research on maintaining and improving the official standards for staple length in cotton. To apply fiber laboratory equipment and techniques to measurement of various physical properties represented in the standard types for staple length, to the selection of cottons used in these types, to checking of types returned because of complaint or question, and from time to time to make laboratory spinning tests to check the accuracy of graduations and levels in fiber properties represented in the official staple-length types.

Research relating to maintenance and improvement of cotton grade standards. To measure integrated and separate grade factors (color, trash, and preparation) by laboratory techniques, both in the standards themselves in order to maintain present standards, and in representative cottons of various crop years for cottons variously harvested and as used in the mill, in order to develop information for improving the standards on a basis of the various grade factors in actual supply and use.

Periodic color surveys of U. S. cotton crop. To study statistically representative portions of selected cotton crops in order to ascertain the range of color, and the proportionate representation of the crop in various grade and color groupings, thus providing a basis for proposing any needed adjustments in future standards.

Determining the stability of color in cotton. To apply laboratory techniques to the measurement of spots and background color of cotton in order to measure the amount and kind of change expected from growth and harvesting under varying conditions, and during storage under various climatic conditions for varying lengths of time.

The development of artificial daylighting for cotton classification. Accurate and consistent use of the standards in classification of cotton requires standardized conditions with respect to lighting. It is customary for cotton to be classed in daylight, and dark days hold up prompt classification. The purpose of this study is to develop specifications for satisfactory artificial daylight.

The development of an instrument for measuring cotton grades automatically. To develop an automatic instrument to measure and indicate the color of cotton, including scales to indicate the grade correlated with each color measurement.

C. History and Evolution of This Work

This work began in 1927 when little was known about the measurement or specifications of the various factors involved in cotton quality. Early work served to develop techniques and instruments by which the cotton standards might be measured. Later work has served to develop information, instruments, and auxiliary equipment that help the classification service to make the standards more regular and more adaptable to use in classification.

D. Funds - Annual Expenditures

Expenditures have ranged from approximately $20,000 to $40,000 per year during the period 1927 to 1949. 1950 fiscal year, $40,000.

E. Examples of Outstanding Accomplishments

Development of the Suter-Webb fiber array device which still provides the most precise research instrument for measuring length and length uniformity of fiber distribution in cotton. While an electronic Fibrograph has since been developed, the Suter-Webb instrument still is used in practically all laboratories where length and length array of cottons is being studied on a research basis.

Development of disk colorimeter (patented early in the cotton grade work) for measuring the color of cotton and many other agricultural products. This instrument has served to measure the cotton grade standards in all the years since 1930-31 when it was first put into satisfactory operation. Devices based on this early work are widely used in laboratories concerned with color measurement of agricultural products. In fact, a whole field of colorimetric practice has arisen on the basis of "disk colorimetry" as developed and adapted in the cotton color laboratory of the Department.

Development, standardization, and publication of basic color work on the Munsell color standards so that today it is possible to interrelate color measurements made in laboratories all over the World, and report them in terms of color as seen, regardless of the instrument used, providing only that measurements are reported in accord with methods now standardized internationally, not merely in terms of a particular instrument as was the usual former practice. This basic work is now used not only for studying the color of agricultural products but in the entire field of American colorimetric practice. In 1942 it was adopted as one section of American War Standard Z44 - The Measurement and Specification of Color.

Color measurements of cotton grade standards made and presented to the last two Universal Cotton Standards Conferences not only helped the staff in preparation of the standards, but also created among the delegates to the conference a better understanding of and confidence in the Department's purpose and efforts in developing standards of quality for raw cotton. Recognition of this was expressed by the delegates in the official minutes of these conferences.

Studies of technical requirements for artificial daylighting, with practical check work under special trial units, has resulted in what might be termed a minor revolution in cotton classing. In 1938-39 when the work began no cotton man would think of classing under artificial lighting. Specifications for "artificial daylighting," as developed in the Department's laboratories (with installations of units for lighting small auxiliary classing areas) were followed up by installation in 1940 of single units in several Government and private classing offices. Few offices seemed much impressed, but in 1947-48 the cotton trade began to follow the Department's specifications with extended, instead of limited, installations, some offices going so far as to exclude natural daylighting in favor of complete installations of artificial daylighting.

Now, ten years after the early work, the trade is so convinced of the practicability of artificial lighting (a steady source of constant illumination reduces variations in cotton classification) that it is testing new types of artificial lighting. The Department's laboratories are now working on technical information as a basis for evaluating these new developments.

An automatic, self-standardizing, easy to operate, electronic instrument for measuring cotton color, developed in cooperation with a commercial instrument laboratory on the Department's specifications, was first shown to representatives of the cotton industry during the 1950 Universal Cotton Standards Conference. The instrument is designed for use in the classing room as an aid to the cotton classer. Previous color work was done in the laboratory by operators highly trained for visual color work; the new instrument requires neither training nor technical skill for operation. Because grade of cotton is highly correlated with the average color of a sample, it has been possible to provide with the instrument a grade diagram so that for a cotton normal in color, trash, and preparation components, grade may be read directly from the instrument. For cottons not normal in the relation of these three factors, the classer is able to judge the grade by use of the instrument with considerably greater precision than has previously been possible. It has wide uses for many segments of the raw cotton industry.

F. Some Additional Work Needed

Color stability studies now under way will not be completed until 1955.

Application of the new colorimeter to problems of standardization for gray and spotted cottons is an important current problem that merits attention as promptly as possible.

A rapid method for scanning cotton for trash content, and combination of this with use of the color instrument, is another problem for additional work.

A better and more rapid method for measuring staple length and uniformity should be developed.

The present scheme of grade standardization should be studied in relation to new methods of harvesting and ginning cotton.

Other properties of cotton besides grade and staple should be studied in relation to standardization so that, whenever it becomes possible, simple classing room procedures may be developed from what may now require more technical, scientific testing methods.

Artificial lighting of classing rooms is in its infancy, and will need considerable investigation and technical assistance during the next few years to see that specifications are made available for adequate minimum requirements.

IMPROVED STANDARDS OF QUALITY AND METHODS OF GRADING COTTONSEED
(PMA - Federal - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

The objectives of this project are: (1) to develop practical means for the grading of cottonseed by individual lots as sold by farmers, (2) to determine the accuracy of the official standards for grading, sampling and analyzing cottonseed in reflecting milling outturns in order to relate the official system as accurately as possible to milling outturns, (3) to determine the effect of variety, growth conditions, moisture and trash content of cottonseed, methods of storage and handling and other factors upon quality and quantity of products from cottonseed as related to cottonseed standardization and grading.

A related line project, RM-c-233.02, on the development of an electronic device for the rapid determination of the oil content of cottonseed is being conducted with RMA funds. That work is limited to a single phase of the development of a simplified system of grading cottonseed, namely the application of electronics to oil-content determination. This regular funds project, on the other hand, covers the other aspects of cottonseed quality, including moisture, foreign matter and free fatty acids content determinations. It is contemplated that equipment and methods for the evaluation of the various factors of cottonseed quality as developed in connection with the respective projects will later be integrated into a complete system of grading.

B. Currently Active Phases of This Work

Improving the present system of standardization and grading of cottonseed. To provide a scientific background, based upon current conditions for the official grading standards. Changes in the crop, in processing techniques and equipment and in relative market value for the various products obtained from cottonseed make it advisable that studies be made periodically of milling outturns in relation to the official grades in order to indicate any adjustments needed in grades so that they will reflect as accurately as possible the milling value of the seed.

Development of a quick, simple, economical method of grading cottonseed. To develop practical means of grading cottonseed in individual lots as sold by farmers to provide an incentive for growers to produce seed of high milling value and to handle the seed so as to assure maximum production of high quality cottonseed products.

C. History and Evolution of This Work

Development of a standard system for the grading of cottonseed was begun about 1915 and was concerned with visual methods of grading such as physical inspection. Little further attention was given this work until 1926 when serious study was given to grading by chemical analysis and, as a result of these studies, a standard system of grading was established in 1932. The research program on cottonseed grading, as at present organized, was initiated during the 1945 fiscal year.

D. Funds - Annual Expenditures

1950 fiscal year, approximately $35,000. Expenditures from 1945 to 1949 varied from $10,000 to $35,000.

E. Examples of Accomplishments

A workable system of sampling, analyzing and grading cottonseed for crushing purposes, greatly needed in marketing cottonseed, was developed by the Department in response to requests from the cottonseed industry. These standards were established in 1932; and in 1937, supervision of the grading system was undertaken at the request of the industry. The voluntary use of these standards has expanded throughout the Cotton Belt until three-fourths of all cottonseed sold for crushing purposes are graded in accordance with official U. S. standards.

Development of a cottonseed moisture meter. One of the four determinations necessary in a quick method of grading cottonseed in small lots is that of moisture content. A rapid moisture determination by an electronic resistance-type meter has been developed by the Cotton Branch and is now undergoing extensive tests.

F. Some Additional Work Needed

Development of a practical method for determining linters content of cottonseed. The development of a rapid, inexpensive method of determining residual linters on cottonseed is needed so that this factor may be included in the grading standards to improve their accuracy. The development of a rapid method of mixing small laboratory samples of cottonseed and simultaneously determining foreign-matter content will speed up and further reduce costs of analyses.

Periodic evaluation of grading system. Changes in varieties of cotton produced, in methods of harvesting and ginning, and in the technology of processing cottonseed will affect the relationship of the standard grades to use value. It will be necessary, therefore, to make periodic studies of this relationship as a basis for indicating any needed adjustments in the standard system of grading in order that such system will reflect as accurately as possible the milling value of cottonseed.

RELATIONSHIPS OF COTTON FIBER PROPERTIES AND OTHER FACTORS OF QUALITY IN RAW COTTON TO PROCESSING PERFORMANCE AND TO QUALITY OF MANUFACTURED PRODUCTS

(PMA - Federal - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

To establish the relationships between the physical properties of cotton fiber and its performance in processing and to provide bench marks for the accurate evaluation and interpretation of the results of cotton quality evaluations for the guidance of various groups in the cotton industry, thereby facilitating technical progress in cotton breeding, ginning, standardization, marketing, and textile processing. The studies involve comprehensive statistical analyses of the extensive data on fiber and spinning test results that have been accumulated over a period of years in connection with research and service testing activities.

B. Currently Active Phases of This Work

Relationship of fiber properties in raw cotton to strength of yarn. To determine the relations and relative importance of the measurable cotton fiber properties to strength of yarn.

Relationship of fiber properties in raw cotton to appearance of yarn. To determine the relations and relative importance of the measurable cotton fiber properties to yarn appearance.

Relationship of cotton fiber properties in (processed) second drawing sliver to strength and appearance of yarn. To determine the relations and relative importance of the measurable cotton fiber properties in second drawing sliver to strength and appearance of yarn; and to compare such evaluations with corresponding ones based on measurements of the same fiber properties in the raw cottons as a possible basis for improving the accuracy of formulae for predicting the spinning performance of raw cotton from fiber test results.

The occurrence of neps in card web as related to the measurable fiber properties in raw cotton and to the appearance and strength of yarn. To determine the relations and relative importance of the measurable fiber properties in raw cotton to number of neps in the card web; and the influence of neps in card web on the appearance and strength of yarn.

C. History and Evolution of This Work

This project, as at present organized, was initiated during the 1943 fiscal year. Prior to that time some limited interpretations were being made of fiber test results in relation to spinning test results on the same lots of cottons. For the most part these interpretations were applied specifically to data obtained in connection with tests made in connection with standardization, marketing and ginning research programs and for tests made on cotton samples submitted by cooperating research agencies. As the volume of such test data increased and the need for more precise statistical evaluations of their significance was recognized, provision was made for so organizing the work as to provide for comprehensive statistical analyses of accumulated data with a view to establishing definitely the relationships of individual factors of raw cotton quality and the performance of the cottons in processing. Subsequently, an expansion in the volume and scope of fiber and spinning testing incident to various research and service activities has resulted in the accumulation by the Cotton Branch of PMA of the most extensive collection of data relating to raw cotton quality, processing performance and product quality in existence any place in the World. This accumulation of data as a by-product of other projects now provides the raw material for the studies being conducted under this project. As the work has progressed, improved techniques of statistical analysis have been adapted to these studies to facilitate the work and increase its accuracy.

D. Funds - Annual Expenditures

1950 fiscal year, $40,000. During the period 1943 to 1949, expenditures have ranged from about $20,000 to $40,000 per year.

E. Examples of Outstanding Accomplishments

Establishment of relationship of various elements of raw cotton quality to processing performance and quality of manufactured product. During the last seven years thousands of multiple and simple correlation analyses have been made for large numbers and wide ranges of cottons covering the crop years 1935 to 1950. Analyses have been made on data stratified by series, crop year, variety, staple length and combinations of staple length. The relations and relative importance of fiber length, length variability, fineness, strength, maturity, and grade have been evaluated for the different conditions, in terms of strength and appearance of carded yarn processed by long draft and by regular draft; and of combed yarn processed by regular draft. The same has been done for those fiber properties in terms of strength and elongation of tire cord as well as of picker and card waste associated with the manufacture of carded and combed yarns. Parallel evaluations have been made for the alternative measures of fiber length and of fiber strength. These findings have been reported in a series of publications and are serving as valuable bench marks of practical use throughout the cotton industry but particularly in connection with cotton marketing and textile processing. The findings developed in connection with these studies are now being used extensively as the basis for technical improvements throughout the cotton industry.

Prediction of strength and appearance of any size of yarn on the basis of a given number of fiber properties. In the analyses referred to in the foregoing, only one size of yarn has been considered at a time. To be able to estimate the strength or appearance of a wide range of yarn sizes, therefore, would require the development of a considerable number of equations and, oftentimes, the further use of a conversion formula. Recently, it has been discovered that the count-strength product or the appearance for the entire range of sizes of yarn spinnable from a cotton can be used collectively in such analyses to many advantages. Thus, by including the factor of yarn size in the regression equation, it is now possible to predict the strength or the appearance of any size of warp yarn on the basis of a given number of fiber properties from only one equation. This development constitutes a definite contribution to knowledge on the relations of cotton fiber properties to various yarn qualities.

Discovery of the associated effects of cotton fiber length and fineness. For many years it had been known that, when spinners were unable to meet minimum strength specifications for their yarns, the simplest thing for them to do was to use cottons of longer staple length. It also was known that, in general, the longer the fibers the finer the fibers. But nobody knew in the early 1930's to what extent such improvement in yarn quality was due to increase in fiber length and how much was caused by the associated increase in fiber fineness. Through the development of a method of approach never used before, involving the mechanical cutting of fibers of extra-long Sea Island cotton to various lengths and recombining them, for spinning purposes, to simulate various fiber length patterns of short and medium staple length American upland cottons, the importance of fiber fineness to yarn strength was disclosed. Thus, it was proved experimentally that the effect of cotton fiber length as such on yarn strength had been overestimated by spinners in the past and by breeders in their cotton improvement programs.

High, positive correlation between cotton fiber strength and yarn strength. For many years, workers in England, Europe, and India endeavored to evaluate the relationship between strength of cotton fibers and strength of yarn. Their findings generally showed a small positive, often insignificant, and sometimes negative relation. In their studies, those workers used strength per single fiber. Using data obtained by the Chandler method for testing the strength of bundles of paralleled fibers, as developed in connection with a related project, a new method of approach developed in PMA's laboratories, a high and positive relationship was reported in 1945 for cotton fiber strength and yarn strength. This was the first time that the much expected relationship between these two variables was effectively evaluated. Similar findings have been obtained later by using data for cotton fiber bundle strength, as determined by the more rapid Pressley method of testing.

F. Some Additional Work Needed

Yarn twist. Inclusion of this important factor of yarn construction as a variable in multiple correlation analyses, together with yarn size and the measurable elements of raw cotton quality, will permit such relationship analyses and findings to be more comprehensive, the prediction equations more flexible, and the estimates of yarn strength, yarn appearance, etc., more applicable to the range of yarn types now being commercially manufactured. The best knowledge and equations available today possess limitations because of the lack of adequate data on yarn twist for their use in general and special correlation analyses.

Fiber spirality. Relationship studies on yarn and fabric quality also need to include the one factor of fiber quality that makes cotton unique and different from any other known plant, animal, or synthetic fibers, namely, spirality. Recent findings from studies conducted abroad strongly indicate that it is the spiral structure of cotton fibers which is the primary cause for their outstanding bending, flexing, endurance, and life-wear properties. Manufacturers of synthetic fibers know this and they are striving hard to inject into their products the so-called spirality of cotton fibers. So far, they have been unsuccessful. Spirality is conspicuous by its absence in current research, testing and improvement programs for cotton. This is so largely because there is no rapid and practical test available for determining the mean number of spirals per unit of fiber length for a cotton and the degree of uniformity in frequency of spirals from base to tip of fibers. The spiral properties probably vary widely with different varieties, growth, and seasonal conditions. Spirality might prove to be an important new target in cotton breeding, production, marketing and utilization. Unlimited opportunities and challenges, therefore, exist for comprehensive studies and evaluations of cotton fiber spirality in terms of spinning quality.

Strand breakage in processing. The relations of cotton fiber properties to breakage of strands during spinning need to be evaluated and their limiting factors established as a basis for the selection of cotton for the more efficient manufacture of specific types of cotton yarn. End breakage in processing is an important factor in cost of processing cotton.

DEVELOPMENT OF IMPROVED EQUIPMENT AND TECHNIQUES FOR COTTON FIBER AND SPINNING TESTING
(PMA - Federal - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

(1) To develop improved equipment and techniques for the testing of cotton fibers, yarns and fabrics that will expedite testing and increase the accuracy of test results, and (2) to develop, install and maintain standard procedures of testing that will assure uniformity of test results between different technicians and different laboratories. The current work is particularly concerned with the development of more expeditious methods of fiber testing and cotton spinning test procedures which are more in keeping with the up-to-date commercial systems of textile processing. In addition work is continually being carried on to bring about better agreement in testing as between two or more like instruments, as between two or more technicians performing the same test, and as between laboratories performing the same test or tests.

B. Currently Active Phases of This Work

Improved instruments and techniques for the testing of fineness and maturity of cotton fibers. To develop improved equipment and techniques for routine quick testing of the maturity of cotton fibers and to correlate the results with the testing of the fineness of the fibers.

Developing a mechanical cotton fiber blender. To develop a machine which will blend a sample of cotton easily and quickly into a homogeneous sample without damage to the fiber.

Standard procedures for fiber and spinning tests. To develop standard procedures for all standard tests and any new tests undertaken in the fiber and spinning laboratories.

Check testing of instruments, techniques and technicians. To provide uniform test material and a system for periodic checking of the level of results for each type fiber and spinning test as performed at each laboratory.

The development of small-scale spinning tests. To explore the possibilities for developing a satisfactory technique for a spinning test on a small sample of 100 grams or less of cotton and to determine the cost and relative reliability of such test.

The determination of optimum processing procedures for specific varieties and types of cottons. To determine the effect on product quality of various procedures in processing in order to develop procedures that will attain maximum end-product quality and best manufacturing performance from the combination of fiber characteristics of particular cottons.

C. History and Evolution of This Work

Prior to the organization of this sub-project during the 1947 fiscal year, work in this field was done as an incidental phase of cotton standardization and marketing research. Basic work on the development or adaptation of equipment and methods for measuring with precision such physical properties of cotton fibers as tensile strength, length and length variability, fineness and maturity as well as the development of standard procedures for conducting small-scale spinning tests had been in progress from about 1927. Initially the emphasis of this work was upon precision in evaluating the various elements of cotton quality with a view to limited application for strictly research purposes. As the applicability of both fiber and spinning testing to a wide range of research problems as well as to practical application in commercial cotton breeding, marketing and textile processing became recognized, the need for more expeditious methods of testing became apparent. The earlier methods were too laborious and time consuming to permit their use on the scale needed for these new fields of application. The work on the project is now concentrated on the development of more expeditious, less expensive, and more accurate methods of testing and on measuring additional elements of cotton quality that significantly affect spinning value.

D. Funds - Annual Expenditures

1950 fiscal year, approximately $50,000. Expenditures have been at about this level since the project was organized during the 1947 fiscal year.

E. Examples of outstanding accomplishments

Reduction in time required for and cost of cotton fiber testing. The cost of complete tests including tensile strength, length, uniformity, fineness and maturity which originally amounted to $14.00 per sample has now been reduced to $4.50 per sample.

Development of the standard 5-pound spinning test procedure, which for most purposes provides a reliable evaluation of the spinning performance of specific lots of cotton. Previously spinning tests required one or more 500-pound bales of cotton and involved costs of several hundred dollars. The present 5-pound test can be made at a cost of approximately $20.00. Thus the development of this test has greatly increased the adaptability of spinning testing to practical problems of cotton breeding, marketing and textile processing as well as for various research applications. Instead of the dozen or so tests per year that could be made when spinning tests were first undertaken in the U. S. Department of Agriculture it is now possible to make more than 3,000 tests per year in the Department's present laboratory facilities.

Development of standards for the appearance of cotton yarns, which have been accepted by the American Society for Testing Materials and are now used extensively throughout the cotton industry in evaluating the quality of cotton yarn.

Development of the Chandler round bundle strength test for measuring tensile strength of bundles of cotton fibers which set a standard for this physical property of cotton.

New test for fiber fineness. Tests of fiber fineness are now being made at a rate approximately 30 times faster than was possible by previous methods and without any loss in accuracy of results. This new technique of fiber fineness measurement was developed in connection with a comprehensive study of all available commercial types of air permeability instruments in relation to standard weight-per-unit of fiber length measurements. A standard direct reading fiber fineness scale was developed as a basic feature of the new technique.

Modified technique for fiber maturity determinations. A modified technique was developed for determining the maturity of cotton samples. The new method is about three times faster than and is just as accurate as the previous standard method. The modified method has now been adopted as the standard and will greatly facilitate fiber testing.

Development of a system of check testing. This, along, with application of long-draft roving and spinning systems for spinning testing, has brought the combined fiber and spinning testing programs to a high degree of development and reliability. Tests on each succeeding cotton crop and statistical analyses account for and explain more and more of the variation in yarn strengths.

The greatest accomplishment is the overall service these testing methods and techniques have rendered as a breeder's tool in the improvement of cotton quality, and as devices for evaluating the effectiveness of ginning developments so far as fiber properties and cotton grades are involved, and as guides in cotton grade and staple standardization and in the marketing of cotton.

F. Some Additional Work Needed

Means need to be developed for the accurate calibration of certain testing devices to produce increased accuracy in the cotton fiber and spinning testing programs.

Routine assembly line systems of testing for neppiness, immaturity, presence of honey dew and other undesirable factors are needed to give wider and ample coverage of tests for these conditions to yearly cotton crops in time to be of advantage in the marketing of the crop.

The significance of the effect of moisture changes, moisture content, and moisture history on the physical properties of cotton fiber, yarns and fabrics need much study. When such relationships are better understood, greater uniformity in cotton classing, cotton standardization, and utilization of specific qualities of cotton for specific end purposes will be possible.

New tests are needed to measure factors in yarn strength not yet capable of measurement. Statistical studies of fiber-property and spinning-performance relationships indicate that approximately 6 to 8 percent of the variance in yarn strength is not explained by the presently-measured fiber properties. New tests should be developed to find the elusive factors and to isolate experimental errors. Accumulation of data showing fiber, yarn and fabric property relationships is needed as a guide to the most effective manner of utilizing different fiber properties and different combinations of fiber properties to the greatest extent in producing special fabrics either woven or knitted for major and specific purposes. Heretofore, these studies have stopped at the yarn stage.

There is a very urgent need for a quick, simple and sufficiently accurate method for the determination of maturity in samples of cotton in the marketing channels. This factor of cotton quality is highly important in relation to the appearance and finishing properties of cotton goods but the present methods for making maturity tests represent a bottleneck in the broader application of fiber testing techniques to practical problems of the cotton industry.

There is urgent need for more adequate and more modern experimental machinery and facilities for conducting spinning tests and related processing studies. The design of a large part of the available and latest developed commercial machinery does not lend itself to a wide range or to a rapid alteration of settings, speeds and adjustments; nor is the degree of precision control sufficient for many lines of the needed program in cotton-quality determinations.

COTTON TESTING SERVICES
(PMA - Federal - State - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

To make cotton fiber and spinning testing services available to Federal and State research agencies and private individuals and firms. The facilities and services of the five laboratories used in connection with the standardization and marketing research program are made available to Federal and State research agencies on a cooperative basis and to cotton breeders, merchants, textile manufacturers and others on a fee basis. A wide variety and range of tests are performed, including physical tests on seed cotton, tests or measurements of the physical properties of cotton fiber, yarn and fabric, and small-scale empirical spinning tests.

Cotton breeders are making extensive use of these services as a means of evaluating cottons in process of development. The fiber tests are particularly valuable to breeders in the early stages of development of new cottons, since they afford a practical means for selecting promising individual plants on the basis of fiber characteristics that are known to be necessary for good manufacturing performance. Much time and work is saved by plant breeders through this process since the unpromising material can be discarded early and emphasis placed on those selections showing greatest promise. Usually by the second year from the selection of individual plants, sufficient cotton is available for standard small-scale spinning tests which are made as a basis for a final decision with respect to the continuance of the cottons in the breeding programs.

Marketing agencies and textile manufacturers are also making considerable use of the testing services as a basis for selecting cottons best suited for the manufacture of specific types of cotton goods. This service is used extensively as a basis for evaluating each new crop and to locate sources of supply of cotton required for specific uses. Public and private research agencies are using these services to evaluate the effects of various cultural, harvesting, ginning, marketing, and processing practices.

B. Currently Active Phases of Work

Cooperative fiber and spinning tests. To provide cotton fiber and spinning testing service to Federal and State research agencies on a cooperative basis.

Cotton testing performed on a fee basis. To provide cotton fiber and spinning testing service to cotton breeders, merchants, textile manufacturers, and others on a fee basis which is designed to cover the approximate cost of doing the work.

C. History and Evolution of This Work

Laboratory equipment and methods for measuring or testing the properties of cotton fibers, yarns and fabrics have been developed in connection with various programs of research on cotton in the U. S. Department of Agriculture very largely during the past two decades. In the early years, this work consisted of large-scale spinning or manufacturing tests in cooperation with textile schools and mills to determine the manufacturing performance of the standard grades of American upland cottons, of cotton of various densities and packaged in various types of cotton bales, and of certain varieties and growths of cotton.

During the 1920's and 1930's, fiber and spinning laboratories were established at Clemson, S. C., and College Station, Texas, a fiber laboratory at Washington, D. C., and a fiber laboratory in connection with the ginning laboratory at Stoneville, Miss. Small-scale spinning tests and more expeditious fiber tests were developed during this period. These developments made fiber and spinning tests a more useful tool and their use was expanded for evaluating the effects of various production and ginning practices. In 1941, Congress authorized the performance of fiber and spinning tests to the public on a fee basis.

With the increase in farm mechanization, increased competition from synthetic fibers, and the availability of testing service to the public during the 1940's, fiber and spinning tests became more generally useful in evaluating the quality of cotton. They were found to be effective in evaluating the effects of various breeding, cultural, harvesting, ginning, marketing, and processing practices and have been used on a continuously expanding scale. More than 25,000 samples of cotton were tested under this project during the 1950 fiscal year.

D. Funds - Annual Expenditures

1950 fiscal year, approximately $51,000. Annual expenditures have ranged from about $15,000 during the 1942 fiscal year to about $50,000 during the 1949 fiscal year.

E. Examples of Outstanding Accomplishments

Assistance in development of improved cottons. All of the cotton breeders of the United States have been assisted, through the fiber and spinning services performed for them, in the evaluation of their new selections of cotton. This has facilitated and expedited the work of the breeders as is reflected in the remarkable progress that has been and is being made in the development of improved varieties and strains of cotton. These testing services have done much to assure cotton producers of planting seed of superior quality from the standpoint of spinning value. Furthermore the progress in cotton quality improvement that to a large extent has been made possible by these services has contributed to the improvement of the competitive position of American cotton in relation to synthetic fibers and foreign growths of cotton.

Aid to technical progress in cotton marketing and textile processing. The testing services made available to cotton merchants have contributed significantly to technical progress in the merchandising of cotton in that merchants have been aided in adopting more precise methods of cotton quality evaluation to supplement customary methods of grade and staple classification. Technical progress in cotton manufacturing has been facilitated by the use of these services in the selection of cotton required to meet product specifications and in the adoption of quality control methods in their processing operations.

Aid to other research agencies. Workers engaged in research on various phases of cotton breeding, production and harvesting have been provided a means for evaluating their work in terms of effects on cotton quality and spinning value.

F. Some Additional Work Needed

Tests of finishing properties and other fabric quality evaluations. There is need for broadening the scope of testing services to include bleeching, dyeing and other finishing properties of cotton fabrics as well as other end product quality evaluations.

It is anticipated that there will be continuing demand for service testing not only by public and private research agencies but also by private firms in the various branches of the cotton industry.

COTTON STATISTICS, CLASSING, STANDARDS, AND FUTURES ACTS
(PMA - Federal-Cotton Acts)

A. Purpose and Nature of Current Work

To serve and safeguard the interest of cotton farmers, ginners, spinners, merchants, and ultimate consumers by fostering orderly marketing and pricing in accordance with quality of cotton through: (1) quality standardization; (2) classing and grading; (3) market news; (4) quality and price reports; and (5) related activities. Currently, work under the Cotton Acts is concerned with cotton, cottonseed, and cotton linters. These services provide a uniform system of describing and grading cotton, cottonseed, and cotton linters which fosters economic and intelligent marketing on the basis of the true quality of the product. It provides producers, merchants, and processors dependable quality information on production and processing performances of the various varieties being produced and provides processors with information as to sources and quantity of the qualities needed. The market news information is widely used throughout trade circles and keeps all segments of the industry from the producer to the consumer informed with timely and accurate information on production, consumption, exports, prices, and much other pertinent information necessary for economic and intelligent trade in cotton and related products.

B. Currently Active Phases of This Work

Cotton Classing Services. The purpose of the work under the classing services is to determine the grade and staple length of cotton for farmers, the cotton trade, and others interested in the quality of cotton. Specifically, the classing services provide: (a) classing services to cotton farmers, manufacturers, and merchants who submit samples for classification; (b) classification of cotton produced by members of groups organized to promote the improvement of cotton, and provision to them of quality and price information for bargaining with buyers to obtain full premiums for improved quality; (c) classification of all cotton intended for delivery in settlement of futures contracts, to provide assurance to purchasers of such contracts that cotton delivered will be of the tenderable quality specified and to provide price information based on market values as a basis for settlement for delivery on contract; (d) licensing and supervision of classers.

Preparation and Distribution of Standards. The purpose of this work is to prepare physical types of the standards for use in the determination of grade and staple length of cotton and the grade of linters wherever these commodities are exchanged.

Market Information and Quality Statistics. Work in this field includes the following activities: (a) current market information on prices, supplies, and demand that will enable farmers to bargain advantageously in the sale of their cotton; (b) supervision of the determination of prices and price differences used in settlement of futures; (c) preparation of quality reports annually on the carry-over and periodically on current cotton ginnings; and (d) the preparation and distribution of quality and price information to farmers for use as a basis for adjusting production to give maximum returns and in line with consumer needs.

C. History and Evolution of This Work

In the early part of this century, cotton trading was conducted primarily on actual samples or based on indefinite descriptive terms such as "Delta quarters", "Memphis Middling", etc. There were no standards for describing cotton other than by point of origin. With improved transportation and more rapid communication, along with the growth of the industry, a demand arose for a system of trading that could be based on uniform descriptive terms. As a result of this demand, tentative standards for the grading of American cotton were first prepared by the U. S. Department of Agriculture in 1909. These standards were revised and improved from time to time until 1914 when the Cotton Futures Act was passed and official standards made mandatory for the purpose of grading cotton under this legislation. The first official classification of cotton was done under the Cotton Futures Act but in 1923 the Cotton Standards Act was passed which made the official standards mandatory for interstate transactions in upland cotton and provided for various classification services and the licensing of cotton classers. The next of the important acts was the Grade and Staple Statistics Act of 1927 which directed the Secretary of Agriculture to compile statistics on the grade and staple length of cotton in the carry-over and crop. Later in 1937 this legislation was amended by the Smith-Doxey Act which directed the Secretary of Agriculture to provide a classification and market news service to groups of farmers organized to promote the improvement of cotton. The growth of the classification service in recent years is illustrated by the following figures for total volume of cotton classed by federal employees: 1946-47, 4.1 million bales; 1947-48, 6.1 million bales; 1948-49, 10.4 million bales; 1949-50, 13.6 million bales. The bulk of the classifications in each of these years was done for farmers under the Smith-Doxey Act.

D. Funds - Annual Appropriations

The first appropriation for this work was made in 1925 for $150,000 and gradually increased to the 1926 appropriation of $188,500. In 1928 with the enactment of the Grade and Staple Statistics Act, the total was increased to $559,199. From 1929 to 1939, appropriations ranged from $869,161 in 1929 to $941,900 in 1939. In 1944, when for the first time a single appropriation was made under the Cotton Acts, the total funds appropriated were $1,188,673. In 1950, $1,712,800 was appropriated for work under the Cotton Acts. In addition, $610,000 was made available under special language in the appropriation act which provided that Commodity Credit Corporation should pay for cotton classed under the Smith-Doxey Act for farmers who receive price support.

Revenues collected and returned to the Treasury under these services, originating from classing and other fees, and the sale of "loose" cotton (samples used in classing that become the property of the Government) under the Smith-Doxey and Standards and Futures Acts are substantial. They amount to a large proportion of total expenditures. Revenues returned to the Government under these acts and services totaled $1,784,776.96 during 1949-50. This was 75.5 percent of total expenditures. The revenues have more than doubled during the last four years.

E. Examples of Outstanding Accomplishments

Official Standards for Grade and Staple Lengths. The official standards for grade and staple length provide a common language for describing American cotton throughout the world. It is estimated that more than 80 percent of all cotton moving in trade channels in the United States is classified commercially on the Federal standards in accordance with the United States Cotton Standards Act. The standards for grades are universal standards and have been adopted officially by the trade associations in eight foreign consuming countries. Official standards for grade and staple lengths have been promulgated and revised from time to time as necessary. For upland cotton there are 13 grades for which physical standards are available and 20 descriptive grades, making a total of 33. Official upland cotton standard types for staple length encompass lengths ranging from 3/4" to 1-3/4". In addition, standards have been developed for American-Egyptian and for Sea Island cotton. Official standards also have been prepared for "preparation". Official standards for linters have been developed and have been used extensively in marketing this product.

Classification. In 1949-50 classifications of cotton totaled 13,600,000 bales of which 10,300,000 were under the Smith-Doxey service for farmers; 1.4 million under Form A (fee classing for members of the trade); .5 million Commodity Credit Corporation loan; .5 million futures; .6 million ECA; and .3 million other. The 10.3 million bales classed in 1949-50 under the Smith-Doxey Act represented 65 percent of the total crop, a new high, against 55 percent in 1948-49. Practically all of the cotton in the western part of the belt is classed, while less than one-third of the crop is classed in some eastern states.

During the 1935-36 season, a study of practices prevailing at producers' local cotton markets was conducted to supply background information necessary for appraisal of problems existing at that stage of the marketing of the cotton crop. The findings indicated that growers generally occupied a very weak bargaining position in selling cotton, but a majority of growers expressed a decided interest in receiving cotton quality and market news information as a guide in marketing. In 1938, governmental services under the Smith-Doxey Act were inaugurated providing both quality and price information for growers.

After such governmental services had been available to growers for more than a decade, a re-study was made in the 1948 fiscal year at 98 of the 101 markets forming the basis for the earlier study.

Cotton growers indicated considerably improved marketing conditions in 1947 as compared with 1935. Growers in 1947 on the whole were found to occupy a stronger bargaining position than in 1935. Proportionately, the number of growers receiving detailed price information prior to selling was twice as great as in 1935. The relative volume of cotton for which growers had impartial quality information at time of sale in 1947 had increased six-fold over than in 1935. Radio aided materially in the wider distribution of market news, and quotations assembled by the Department formed the chief basis for such broadcasts. The main source of impartial classification for growers was provided by the Smith-Doxey Act whereby cotton samples are sent in to be classed and a postcard on which is recorded the Form 1 classification is returned to the producer, usually on the same day the sample is received.

The Smith-Doxey (Form 1) classing service represented the one major innovation occurring during this 12-year interval. In 1947-48, about 47 percent of the cotton moving through the selected markets was marketed on Form 1 classification. Growers participating in the program submitted about 90 percent of their total crop for classification. All growers at markets in Arizona, California, and New Mexico, 70 percent of those in Missouri, about 50 percent of the growers in Arkansas and Mississippi, and approximately 33 percent of those in Georgia, Oklahoma, and Texas reported receiving a Form 1 classification on their cotton.

During this same period, the quality of the crop from the standpoint of staple length has improved substantially. As an increasing proportion of the farmers receive payment based on quality, they have given more attention to variety planted and improved cultural and harvesting practices. As a result of this and various other factors the number of varieties produced has declined sharply to where a very large proportion of the entire crop consists of about 8 to 10 of the more desirable ones.

Since these services have been available to farmers, the average length of the United States crop has increased more than 1/16 of an inch and now averages well over one inch.

Market Reports. Basic information on prices, stocks, production, consumption, exports, and imports for cotton and linters have been widely disseminated through the Weekly Market Reviews, Cotton Price Statistics, and quality reports on the crop and the carry-over. This information is being used to an increasing extent by local radio stations, national trade publications and local newspapers, and has proved helpful to all phases of the cotton industry from producer to consumer.

This basic information with respect to cotton and linters, has been essential to the development and operation of price support, production and other control programs necessary during World War II. If such controls should be necessary in the future, this basic information will be invaluable.

F. Some Additional Work Needed

Constant and additional studies are needed to keep the cotton grade standards in line with changing production and also to improve the efficiency preparation and use of these standards. The supervision of classification performed by the Department could well be strengthened and particularly the supervision of classification by licensed classers should be improved and expanded. Additional checking and verification is needed in supervising the ten market quotations. Constant study and improvement in sampling the crop and carry-over for quality estimates reports is required and the market news service under these Acts should be strengthened to insure that accurate price information is being received and disseminated.

IMPROVING MARKET OUTLETS FOR VARIOUS KINDS OF COTTON IN RELATION TO MERCHANDISING PROCEDURES
(PMA - RM-c 70 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

To improve market outlets for the various kinds of cotton by determining: (1) the types and qualities of cotton best suited, from the standpoint of both economic and technological factors, to the manufacture of each of the principal types of products made from cotton, (2) the adaptability of each variety and strain of cotton as grown in various producing areas to specific end uses, (3) the quantities of cotton required for each of the principal types of cotton products at various levels of textile production, (4) the aggregate available market outlets for cotton of each type and quality and, (5) the relation of production of cotton of various types and qualities to available market outlets.

Comprehensive studies are being made of the various quality factors of raw cotton used by representative mills manufacturing each of the principal types of cotton products and of the results being obtained in terms of processing performance of the cotton as well as the quality of the manufactured products. The samples from mill mixes are processed in the textile laboratories of the Department for comparison with results obtained from commercial production in the mills.

The adaptability of each of the principal varieties of cotton now in commercial production for use in various types of products is being determined by a series of laboratory and technically supervised large scale tests.

The work being done under this project differs from related studies being conducted with regular funds in that this work is based primarily on results of tests of samples obtained from mill mixes of raw cotton actually being used for the manufacture of specific products and on the results of tests of samples of the manufactured products. Likewise the phase of this work having to do with determining the relative suitability of different commercial varieties for the manufacture of various cotton products involves the large-scale empirical testing, under contract with a textile research laboratory, of typical lots of cotton of each variety for the manufacture of specific products. Studies being conducted under the regular funds project entitled "Marketing Practices of Cotton Mills in Procuring Cotton of Qualities Needed in Relation to Qualities Produced by Crop Improvement Groups" are based on surveys of cotton mills to ascertain practices and preferences of cotton manufacturers in the procurement of raw cotton and on annual tests of the fiber and spinning qualities of cottons being produced commercially in crop improvement areas. The latter phase of this regular funds project is designed to indicate to cotton manufacturers and merchants sources of cotton of specific fiber and spinning characteristics and to aid producers of such cotton in finding market outlets for their product.

B. Currently Active Line Projects

RM-c-70-1 - Determination of the raw cotton requirements for specific cotton products, and the extent of market outlets available for various types and qualities of cotton. To determine the extent of market outlets available for cotton of various types and qualities by ascertaining the types and qualities of cotton now used in the manufacture of each of the principal products made from cotton, by relating the qualities of cotton used to the characteristics of the various improved varieties and growths of cotton, and by relating the quantities of cotton goods manufactured to aggregate quantities of the various types and qualities of raw cotton required.

RM-c-70-2 - Determining the suitability of different varieties of cotton for use in specific end use products. To determine by laboratory and commercial mill tests the technological and economic suitability of each of the principal varieties of cotton now being produced commercially for use in the manufacture of various cotton products.

C. History and Evolution of This Work

This project was started in September 1947 as a result of requests from various branches of the cotton industry for more detailed information on the types and qualities of cotton required for the manufacture of the various textile products. In several earlier studies, an attempt was made to develop information with respect to the qualities of cotton required for best results in the processing of various cotton products as based on statements of mill officials. It became evident from previous studies that the obtaining of dependable data would require the sampling and laboratory testing of the raw cotton actually being used by mills for the manufacture of specific products. The use of samples from mixes from representative mills makes it possible to get detailed and authentic data on the quality of cotton used and furthermore this method permits mill performance to be matched against results obtained in the laboratory. Part of this work is being conducted through contractual arrangements with a State Textile School.

D. Funds--Annual Expenditures

Expenditures for the 1948 fiscal year were $20,000, 1949 $58,300 and for 1950 $72,000.

E. Examples of Outstanding Accomplishments

The publication "Market Outlets for Cotton in Some of the Principal Cotton Fabrics", published in February 1949, provides definite information with respect to averages as well as the limits of the range for each factor of quality in the raw cotton being used for the manufacture of each of 10 important cotton products; trends in consumption of cotton in each of the 10 products; the market outlets for cotton in each product; variety or varieties of cotton deemed most suitable for each of the products; and factors affecting the amount of cotton consumed in each product. The aggregate available market outlet for cotton in the 10 products is approximately 3 million bales at current levels of consumption. This information is of direct value to the cotton industry in providing bench marks with respect to raw cotton quality and product quality for each product included in the study. Producers of cotton suitable for these products are provided an indication of the extent of available market outlets in specific products. A by-product of the study of direct advantage to the cooperating mills is the technical laboratory data made available to them in connection with the raw cotton and product samples furnished by them for use in making the study. This aspect of the study is particularily important to the small mills that are not in a position to provide their own laboratory facilities.

The project has been in progress only a short time. The full advantages to the cotton industry of the information being developed will become more apparent as the work progresses to include a larger number of cotton products.

F. Some Additional Work Needed

Additional products should be studied. The studies should include all of the principal cotton products. For instance, the study of market outlets for extra long staple cotton (1-3/8 inches and longer), recently initiated, needs to be pursued vigorously because the 1950 U. S. production of such cotton promises to be many times larger than it was in 1949. Heretofore, this country has been dependent upon foreign production for most of its extra long staple because of special quality features of the foreign cotton. This study could help in finding the best uses, advantages and limitations of extra long staple cotton of the domestic varieties currently produced.

Tests on 10 major products should be repeated. Tests relating to the 10 fabrics already reported on should be repeated within a year or two to measure the effect of different crops on the quality of cotton used by mills and on the quality of the product. Further study is needed to determine more precisely the specific qualities or range in qualities that best serve the needs for each fabric. Only a beginning has been made in studies relating to the suitability of different varieties of cotton for specific products and this study should be continued and expanded to include all varieties of cotton now being produced and all of the principal cotton products.

Additional research could profitably be given to a number of other problems including the following:

Factors affecting the consumption of specific cotton products. This work should include thorough analysis of elasticity of demand for each product, in order that more accurate estimates can be made of probable available market outlets for various types of cotton under varying economic conditions.

The effect of variability of quality in mill mixes. The objective of this study would be to ascertain the extent to which blending of different qualities in mill mixes can obviate the need of using only cotton of even running quality.

COTTONSEED GRADING
(PMA - Federal Market Inspection of Farm Products Funds)

A. Purpose and Nature of Current Work

This work provides farmers, ginners, and oil mill operators with a grading service for cottonseed to enable them to market the cottonseed crop intelligently and to obtain prices in proportion to quality. The quality of cottonseed can change significantly and quickly within relatively small territories and over a short time so that a grading system is necessary for intelligent marketing.

B. Currently Active Phases of This Work

Under the present system, chemists are examined and licensed to perform cottonseed grading on a fee basis. Licensed chemists issue grade certificates showing a complete analysis of each sample graded for all grade factors. Their work is under federal supervision. About 151,135 certificates were issued on samples of cottonseed graded from the 1949-50 crop and approximately 155,521 certificates were issued for the 1948-49 crop. These certificates were used in reports on the quality of cottonseed by counties of origin, presented in the weekly cottonseed review in the southeastern, south central, and southwestern areas. They were also the basis for preparation of the annual quality report on cottonseed published each year by the Washington office.

C. History and Evolution of This Work

As cottonseed progressed from a waste product to a valuable raw material, there naturally rose a demand for a measure of quality. The quality of cottonseed depends on a relatively large number of factors and therefore the development of procedures and standards was difficult. The first Federal standards for grading cottonseed were promulgated in June 1932. There have been a number of improvements since that time. Official grading of cottonseed has become general in most of the southwestern south central and southeastern sections of the Belt. It is not general in the far western states. The present system of grading is suited to fairly large lots of seed and is used principally in transactions between ginners and oil mills. So far a system has not been developed that is adapted to the grading of small lots sold by farmers to ginners.

D. Funds - Annual Expenditures

The first appropriation for this work was made in 1938 in the amount of $20,000. An additional $5,000 was appropriated in 1939. Since that time only funds for salary increases, overtime, within-grade salary advancements, etc. have been added. In the fiscal years 1949 and 1950, appropriations averaged about $35,000. Fees collected for deposit into the Miscellaneous Receipts Account of the Treasury from cottonseed certificates and the licensing of chemists and samplers, have more than offset expenditures under the appropriation for this activity for each fiscal year since 1942.

E. Examples of Outstanding Accomplishments

It has been possible from the individual grade certificates to prepare at the end of the season a bulletin showing statistics for each of the quality factors of cottonseed, by months during the active season and by crop reporting districts, for all states in which seed is graded. The grading system has aided orderly marketing and provided ginners and oil mills reliable information which allows them to pay for cottonseed on the basis of quality. This has benefited farmers, as in most areas cottonseed is marketed on a highly competitive basis. These data also furnish sound historical background information for judging future operations. These certificates furnished valuable information used in establishing price support programs both during and since World War II.

F. Some Additional Work Needed

It would be highly desirable if seed grading were adopted in the far western states also.

There is a need for the development of a system for economically and quickly grading cottonseed in small lots which would enable farmers to sell their seed on the basis of quality.

CROSS REFERENCES - MARKETING

For additional information on subjects reported on in this chapter, see also:

BAE - B-1-1, Chapter 32, field crop estimates and reports.
BAE - A-2-16.1 to 24.1, Chapter 26, research and analysis for servicing current requests.
BAE, FCA, PMA - RM: c-110, Chapter 11, effects of new oilseeds and fats and oils processing techniques on market, etc.
BAE - RM: c-205 and a-2-16, Chapter 26, marketing practices.
BHNHE - b-2-1, Chapter 26, rural family living in shifting cotton economy.
BPISAE - e-3-4, Chapter 30, consolidation of ginning, oil milling enterprises.
CEA - Commodity Exchange Act, Chapter 35.
EXT - RM: c-95, Chapter 37, cotton marketing.
FCA - a-1-1, Chapter 11, assistance to cotton and oilseed cooperatives.
OES, FCA - RM: c-558, Chapter 26, operating efficiency of agricultural marketing cooperatives.
OFAR - RM: c-2, Chapter 23, foreign activities.
OFAR - RM: c-544, Chapter 23, foreign activities.
PMA, FCA - RM: c-75, Chapter 36, market facilities, organization, and equipment.
PMA - RM: c-189, Chapter 11, improving marketing facilities, equipment, and storage methods for oilseeds and their products.
PMA - RM: c-233, Chapter 11, improved methods for grading oilseeds.
PMA - RM: c-382, Chapter 11, new and expanded outlets for oilseeds.
PMA, OES - RM: c-411, Chapter 11, reduction of marketing costs and margins by improving marketing methods for cottonseed and cottonseed products.
PMA - RM: c-430, 431, 432, Chapter 36, marketing service programs.
PMA - Cottonseed market news, Chapter 33.
PMA, Administration of U. S. Warehouse Act, Chapter 35.

HARD FIBER PRODUCTION, BREEDING, DISEASE, AND QUALITY INVESTIGATIONS
(BPISAE - a-3-1 - Federal-State)

A. Purpose and Nature of Current Work

To (1) aid in safeguarding our required supply of abaca, sisal, and henequen which furnish strategic raw material for marine cordage and other types of cordage considered essential by the Navy and for binder and baler twine; (2) encourage the increased production of fibers of the desired qualities of abaca, sisal and henequen, and a suitable substitute for these fibers in regions of Latin America having conditions favorable for their production; (3) secure and disseminate information that will aid in the development of this industry; (4) survey and make recommendations for the research on the control of pests and diseases that are hampering the progress of this essential industry in Latin America; (5) help maintain satisfactory and reliable standards of qualities on these fibers.

B. Currently Active Line Projects

a-3-1-8 - Abaca, sisal, henequen, and other hard fibers not produced in the United States. The chief objective of this project is production of abaca, sisal, and henequen of the desired qualities for cordage purposes, but exploratory work is being done in an effort to find suitable substitutes for these fibers in regions of Latin America having conditions favorable for their production. In order to accomplish this end and to aid in safeguarding our required supply of these fibers, information is secured and disseminated that will aid in the development of this industry. Problems are surveyed in order that properly organized research for control of pests and diseases can be recommended when needed. Laboratory tests are being made at Beltsville to evaluate the physical properties of these fibers and their substitutes in order to maintain satisfactory and reliable standards of quality. Some of the line projects formerly under a-3-1 have been absorbed in a-3-1-8. Some have been discontinued and others have been absorbed in line projects under g-5-0.

C. History and Evolution of this Work

In the early 1900's research on these fibers by the Bureau included extensive studies of Philippine abaca and other imported hard fibers. Studies were made on agronomic and ecological factors influencing production and quality. Plant introductions of abaca were made under this project from the Philippine Islands to Latin America in 1925, and the nucleus of an industry was established there. The abaca industry there has since grown to be of major importance.

Later, a project was started in Florida to explore the possibilities of domestic production of hard fibers. This exploratory work brought to light the value of sansevieria which is considered by the Navy and Munitions Board to be an exceptionally good and extremely important substitute for abaca. It is now being studied under a project on strategic materials. (g-5-0-1).

A fiber laboratory was also established by this Bureau to study the quality of fiber from different parts of the world and to evaluate potential substitutes. A continuing function of the laboratory has been fiber evaluation for agronomic studies. The function of the laboratory has not changed essentially and it is being carried mainly under the project but also supplemented by two other work projects on fibers other than cotton in the Division of Cotton and Other Fiber Crops and Diseases.

Survey, advisory and fiber testing work have been the major activities of the project in its present status. A recent survey under this project has been the basis for setting up the extensive research program under a recent special Congressional appropriation for abaca expansion in the Western Hemisphere. (A number has not yet been given to the new Latin American research project.)

D. Funds - Annual Expenditures

The annual expenditures for this work project from 1946 through 1950 averaged about $23,000. During the very early stages of this work it was not divided on a project basis of this type. During the 1930's the annual expenditures were about $6,000 to $9,000 annually. In 1942 they were $9,287; in 1943, $11,500; in 1944, $19,050; in 1945 they were $20,050.

E. Examples of Outstanding Accomplishments

Exploratory work under this project established the value of Sansevieria fiber and demonstrated it could be grown in Southern United States. This was the basis for the research program on this crop that is now underway in Florida.

Introduction of abaca from the Philippine Islands into Latin America in 1925 proved first that abaca could be produced in the Western Hemisphere and at the same time provided planting material for the expansion that has since taken place. The extreme importance of this introduction of abaca into the Western Hemisphere is well recognized.

F. Additional Work Needed

There is a need for refinements in the technique of testing hard fibers and detailed and extensive tests on the relation between laboratory results and the mill results of spinning, the strength of the product and its resistance to deterioration and wear under actual service performance conditions to which marine cordage is subjected. Some system similar to the related fiber and spinning tests now employed for cotton fiber is badly needed for evaluating hard fiber quality.

Study of the tip-over disease of abaca. The condition commonly known as tip-over disease in the Western Hemisphere has been causing disastrous damages in many localities. It is essential to definitely identify the cause and develop corrective measures. In addition to need for research on disease and insect problems of abaca, studies of nutritional and cultural requirements of the plant should be undertaken.

HEMP, FLAX, RAMIE, URENA, CROTOLARIA AND MISCELLANEOUS FIBERS
(BPISAE - a-3-2 - Federal-State - Regular funds)

A. Purpose and Nature of Current Work.

To (1) conduct field and laboratory investigations of selected strains of certain fiber crops in order to improve yields and fiber quality, (2) develop more efficient agronomic practices, and (3) develop information on biological factors affecting retting and processing. Some of the miscellaneous fibers are studied in relation to their adaptation and value to American agriculture.

B. Currently Active Line Projects.

a-3-2-1 - (Rev.) Developing improved cultural practices for fiber flax production. Determine agronomic practices that improve quality of fiber and increase fiber yields.

a-3-2-2 - (Rev.) Fiber flax improvement. To develop and maintain varieties of improved fiber quality and increased yield by hybridization, selection and testing.

a-3-2-3 - (Rev.) Retting studies with fiber flax. To determine factors that influence the retting of flax in order to develop practices that will improve fiber quality and increase the financial returns from fiber flax production.

a-3-2-10 - (Rev.) Malvaceous fiber investigations. To investigate cultural practices, varieties, and processing methods that will increase production, lower costs and produce an acceptable jute substitute.

a-3-2-12 - (Rev.) Ramie fiber investigations. To develop methods of culture and fiber preparation that will lower production costs and produce a product that will compete with imported ramie and other textile fibers during normal times and provide a fiber of a quality that will be useful for strategic purposes.

a-3-2-13 - Miscellaneous fiber investigations (nettle, apocynum, sesbania, hops, grasses, zacaton, palm fibers, euphorbia, also fibers for stuffing, paper, brushes, etc.). To study, record and disseminate information on miscellaneous plant fibers other than hard fibers not covered in other projects under a-3-2.

a-3-2-14 - Hemp culture and improvement. To produce varieties of hemp more productive of high quality fiber and adapted for different environmental conditions, to test and improve a monecious strain of hemp that has recently been obtained and maintain varieties with low marihuana content.

C. History and Evolution of this Work.

Plant fibers covered by this project assume considerable importance during a national emergency. Many leaf and stem fibers have a minor role in American production in time of peace but are important in

Page 184, insert as last line of page: "time of National emergency. Research on flax and hemp has been--"

conducted by the Department of Agriculture for many years and most of the varieties being grown now have resulted from this work. Much less attention has been given to the other fibers covered in this project. They have many important uses, however, that cannot be overlooked.

At the outset of this work in about 1909 the main emphasis was on the selection and testing of new strains of fiber flax and a determination of the optimum planting and harvesting date, cultural requirements and fertilizer requirements. These were studied for the conditions in Michigan which was at that time the center of the fiber flax growing area of the United States. Later the industry was shifted to Oregon and it was necessary to make the same agronomic studies for that area. Furthermore the varieties that were found adapted to the mid-west did not prove satisfactory in Oregon. Similar tests were therefore necessary in that area on both agronomic and breeding phases of the work. In addition, a hybridization and disease resistance study was given particular emphasis in connection with the work in Oregon. At this time the emphasis is being shifted away from cultural experiments and directed toward the development of winter varieties, and the effect of irrigation on certain phases of agronomic practices. It is necessary to continue breeding for yield, fiber quality and disease resistance, in order to maintain varieties resistant to diseases that are currently prevalent.

The research on hemp concerned breeding and agronomic studies for several years and the answers to some of the more important questions were worked out for the hemp growing area at that time in Wisconsin. That research was discontinued and a new line of work undertaken for the study of the adaptation of hemp to some of the less fertile areas on the borders of the corn belt. Attention now is being directed toward yield, fiber quality, and cultural practices in the field and toward seed storage conditions in connection with stockpiling.

The ramie and other soft or stem fiber work has been conducted for the most part in the state of Florida at the Everglades Experiment Station although experiments have been carried out on a cooperative basis throughout the Southern states. The work on these crops has never been extensive and has been concerned primarily with testing the adaptation of various species to conditions in the United States, although in the case of ramie limited tests on cultural practices, fertilizers and strains or varieties have also been included.

D. Funds - Annual Expenditures.

The annual allotments for these projects have fluctuated from minor part time jobs in the early part of the century to $43,600 in 1946 and $30,070 in the fiscal year 1949-50.

E. Examples of outstanding Accomplishments.

Determination and publication of factual information on optimum agronomic practices. Such results were necessary information for a successful flax industry. Determinations were made in

Oregon and Michigan.

Variety improvement. The development of the Pinnacle variety of fiber flax which was disease resistant and highly successful in the Michigan area. The introduction and testing of the Cirrus variety of fiber flax which was a great improvement over the varieties being grown in Oregon at the time it was introduced. The Cascade variety has been found extremely productive in the state of Oregon. It is disease resistant, being almost immune to rust, one of the worst diseases in that area. It was produced by hybridization at the Oregon station. The hemp variety now grown resulted from early breeding work under this project. This open pollinated strain has been found very successful and productive in the present hemp growing area.

The determination of retting techniques to improve fiber quality. Certain retting procedures were found that gave somewhat better yield of fiber without injuring the fiber or added cost. Many of these have been adopted by the industry.

Testing miscellaneous fiber plants. Miscellaneous fiber plants have been grown in experimental tests at different times and locations to record factual information in reference to their productiveness, thus giving information on their economic feasibility for culture in the United States.

F. Some Additional Work Needed.

The study of winter varieties and winter production of fiber flax. Flax planted in the fall could take advantage of the early spring rains and the cool moist growing season prevalent in Oregon. There are many problems such as weed control by cultural practices, winter hardiness, lodging etc., which have to be studied before it can be recommended as a commercial practice. There are no good varieties of winter flax available and these would need to be developed.

The effect of irrigation on agronomic practices. The past research program has given the answers to many of the agronomic problems connected with fiber flax production but the proper practices under irrigated conditions have not been adequately investigated. Additional attention should be given to this phase of the work. Also, the response of different varieties under irrigated conditions should be studied.

The retting of flax is tied up with many questions to which more specific information is needed.

All of these proposed studies should be made with attention to both yield and fiber quality.

FIBER FLAX HARVESTING AND PROCESSING MACHINERY INVESTIGATIONS
(BPISAE - e-3-2 - Federal-State-Regular Funds)

A. Purpose and Nature of Current Work

To develop flax harvesting and processing machinery which will reduce labor requirements, increase capacity, and preserve the inherent good quality of the fiber and in turn increase returns to the growers. Attempts were first made in Europe to mechanize the harvesting and to industrialize the processing of the crop but the equipment and methods were not suited to American conditions. Work under this project, therefore, is directed toward developing a complete line of labor saving equipment for both harvesting and processing operations. Although the production of fiber flax is limited to a relatively small area in this country it is an essential industry and flax fiber is used in large quantities. Its importance is shown by the action of our Government during World War II when production was augmented by subsidies and other means in an effort to secure large quantities of this strategic fiber.

B. Currently Active Line Projects

e-3-2-1 - Pilot plant for fiber flax processing operations. To obtain information on fiber quality and processing costs from an experimental processing line using improved equipment under commercial conditions.

e-3-2-2 - Artificial drier for retted fiber flax straw. To develop an artificial drier for retted fiber flax straw in order to change the present seasonal nature of the work at flax mills to that of a continuous year-round operation.

e-3-2-3 - Bulk handling of fiber flax straw. To develop equipment and techniques for the bulk handling of bundles of straw at fiber flax processing plants.

e-3-2-4 - Self-propelled fiber flax puller. To develop a high capacity self-propelled machine which will pull flax with a minimum of damage to the straw and tie it in neat bundles with even root ends.

e-3-2-5 - Retted straw straightener and spreader. To develop a mechanical device for operating and straightening retted flax straw prior to scutching for increasing fiber yields and scutching machine capacity.

e-3-2-6 - Automatic string cutter for fiber flax bundles. To develop a machine which will automatically cut and remove the binder twine from bundles of pulled flax strawprior to deseeding and from bundles of retted straw prior to scutching.

C. History and Evolution of the Work

Fiber flax investigations dealing with harvesting and processing machines were begun cooperatively in Oregon in 1939. An engineering analysis of the industry determined where in the chain of used had been imported from Europe and generally was not well adapted for use in this country. Sufficient progress in machinery development was made in time to assist in expanding the industry to supply flax fiber needed during World War II. However, some of the major developments in processing machinery were not made in time for use during the war and work has continued in an effort to make the domestic flax industry profitable for the producers and processors under peace-time conditions.

D. Funds--Annual Expenditures

Annual expenditures of regular funds for fiber flax machinery investigations ranged from approximately $25,000 in 1939 to $47,160 in 1950.

E. Examples of Outstanding Accomplishments

The development of a rotary comb deseeder to increase labor efficiency. This type machine for which a public patent wasobtained reduced the labor requirements from approximately 10 to 3 man-hours per ton of straw. The use of this machine on about 9,000 tons of the 1946 crop in Oregon resulted in an estimated saving in labor of approximately $63,000.

The development of tow cleaning equipment. Fiber flax tow, a tangled mass of fiber resulting from the scutching operation, was at one time almost a worthless by-product at Oregon mills. The tow cleaning equipment development resulted in the sale of over $70,000 worth of tow at a time when there was no market for the uncleaned product.

New fiber flax scutcher increased yields of line fiber. A scutching machine with improved straw breaker, new type gripping device and combs for extra cleaning raised the yield of line fiber about 2 percent. With line fiber at 50 cents a pound, the machine increased the value of pulled flax as delivered by the farmer approximately $10 per ton. On the basis of peak World War II production the machine would have increased the value of the Oregon flax fiber crop by approximately $250,000 per year.

F. Some Additional Work Needed

With the development of an artificial drier for retted fiber flax straw to change the present seasonal nature of work at flax mills to that of a continuous year-round operation, and the collection of information on fiber quality and processing costs from an experimental processing line using improved equipment under commercial conditions, the project will be terminated.

PRODUCTION AND PROCESSING EQUIPMENT FOR SPECIAL FIBER CROPS

(BPISAE - e-3-3 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of these investigations is to improve the possibilities of producing in this country such needed fibers as those used for rope, cord, binder twine, bagging, carpet and linoleum backing, and many other purposes in industry. Normally, the fibers of this type used in the United States are imported from Europe, Asia, the Philippines, or Latin America. Because imported fibers are usually grown in countries with low labor costs, American operations must be completely mechanized if fiber costs are to be kept in a competitive range. The investigations have been limited to the development of machines for those fibers that can be planted, cultivated, harvested, and processed by mechanical means.

B. Currently Active Line Projects

e-3-3-1 - Sansevieria production and processing equipment investigations. The leaves of sansevieria are probably the best substitute known for manila hemp. Machines have been developed for transplanting, harvesting, and decorticating this fiber on a purely experimental scale, but the costs of production and processing have yet to be determined.

e-3-3-2 - Ramie production and processing equipment investigations. Ramie is a plant producing a fiber that has many possibilities for use in textiles and in industry. The object of this project is to develop and adapt machinery for the planting, growing, harvesting, and processing the crop.

e-3-3-3 - Develop production and processing equipment for Kenaf and other jute fiber substitutes. Jute is used for all kinds of bagging, sugar sacks, cotton bale covers, gunny sacks, hessians, upholstery webbing and tow, cord and twine, and many other purposes. The most promising substitute for jute seems to be kenaf. This project is concerned with development of machines for production and processing of kenaf.

C. History and Evolution of This Work

This work was initiated in 1943 as a part of the Department's war effort, and the primary objective was to study the possibility of producing and processing sansevieria fiber. At a later date, the War Production Board made funds available for two years to the cooperating Florida Agricultural Experiment Station for research on ramie. After the close of the war, jute was so scarce and so high priced that work on jute substitutes was added to the Federal program.

D. Funds--Annual Expenditures

On the average, about $35,000 per year since 1943, and $37,460 in 1950.

E. Examples of Outstanding Accomplishments

Machines have been developed for cutting sansevieria leaves into suitable portions for planting the leaf segments in the ground. A harvester has been built which will cut and bind leaves as short as 20 inches, with little loss. After many trials, a decorticating machine has been designed which scrapes the pulpy part of the leaf from the fiber with a minimum amount of broken or waste fiber. An artificial drier has been designed and built which quickly dries the fiber as it comes from the decorticator without injury to fiber quality.

Machines for digging, cutting, and planting ramie roots have been perfected. A harvester, based on those used in cutting American hemp during the war, has been found to work quite well with ramie. The decorticator built for sansevieria has been adapted to serve also for ramie. Decorticated ramie has to be degummed before the fiber is dried, and a continuous degumming process has been developed with a capacity equal to that of the decorticator and the drier.

F. Some Additional Work Needed

For all of these fibers there is need for development of portable decorticators to remove the fiber in the field. Such a machine would save hauling the entire leaf or stalk from the field to the processing plant, and hauling the waste material away from the processing plant. Since about 95 percent of the hauling costs are for waste material, the savings would be considerable. The mechanical problems involved are quite complicated.

Accurate cost figures should be obtained covering all items involved in the finished fiber. If 100 acres of each of the fibers could be set up for experimental work, much information as to economical size of plantings, size of processing plant, and other factors could be determined. Such plantings also would provide planting stock and seed for a quick expansion of fiber production in an emergency.

There is need for study of the kind and amount of processing necessary to meet the quality requirements of the various end uses, and of the prices which the various qualities of fibers might be expected to bring in an open market. These facts will have to be determined before a final report as to the feasibility of the commercial production of any of these fibers can be prepared.

RESEARCH ON DOMESTIC PRODUCTION OF STRATEGIC FIBERS
(BPISAE - No. g-5-1 - Federal - State -
Strategic and Critical Agricultural Materials)

A. Purpose and Nature of Current Work

These studies are directed toward the commercial production in the United States of hard fibers and extenders not now grown or utilized extensively in this country as possible emergency substitutes for normal hard fiber supplies, now almost entirely of foreign origin. This project, in part, supplements work done by BPISAE under projects No. A-3-1 and A-3-2.

B. Currently Active Line Projects

g-5-1-1 - Sansevieria production investigations. To determine locations, soil types, cultural methods, production practices, species, and varieties best suited to fiber production in the United States and to build up planting material sufficient to establish a nucleus of an industry that could be rapidly expanded during a national emergency.

g-5-1-2 - Phormium investigations. To study climatic conditions, soil, and agricultural practices best suited to phormium production in the United States and to determine species and varieties that are best suited to our conditions and consumers' requirements.

g-5-1-3 - Yucca fiber studies. To make studies of fiber yield and quality as affected by age of leaves, species, environment, and method of extraction.

C. History and Evolution of this Work.

In recent years approximately 179,000 long tons of tropical hard fibers are imported annually for domestic consumption. Domestic cotton, wool, and synthetic fibers are not suitable for the needs filled by these imported hard fibers. The Munitions Board is particularly concerned with emergency supplies of extenders for abaca and sisal cordage fibers. Regular funds available to the Bureau have permitted only limited exploratory studies in this field, inadequate to supply information that would be necessary to properly supply emergency needs. The Navy has indicated that sansevieria is the most promising substitute for abaca and marine cordage, and exploratory work indicates that this crop offers possibilities of production in the United States. Phorium, a hard fiber with very wide climatic adaptation, might be used as a substitute for sisal and is well adapted to a temperate climate as in the United States. Yucca, which grows wild in Southwestern United States, has a high percentage of hard fiber which could be used as a sisal substitute for some purposes. During World War II extensive surveys of stands were made, species were identified and the extent and concentrations of distribution estimated. Fiber quality studies are now being completed to supplement the information obtained in the past.

In 1949 an allocation of funds for research on strategic and critical agricultural materials permitted the initiation of an organized research program to determine the possibility of establishing a small nucleus production industry of strategic fibers in this country and to determine the possibility of expanding these in times of national emergencies.

D. Funds--Annual Expenditures

Funds come from Research on Strategic and Critical Agricultural Materials, Department of Agriculture, and the first year of the project, fiscal year 1950, amounted to $50,000.

E. Examples of Outstanding Accomplishments.

Determination that Sansevieria trifasciata is much superior to the S. guineensis in tall growth (desirable for mechanical processing) and frost resistance.

Surveys have established proof that phormium is more adapted to our Pacific Coast region than earlier evidence had indicated.

Studies on yucca have provided information on the acreage, yield and quality of wild yucca stands in case it ever becomes necessary to have an immediate source of fiber in an emergency.

F. Some Additional Work Needed

Plant Breeding with Sansevieria. There has been practically no plant breeding done anywhere in the world with sansevieria. The possibilities of improving this crop by breeding work are great. High fiber content, rapid rate of growth, tall growth habit, and other desirable characteristics are to be found in several different species. Many of these species can be crossed and offer a wide field for improvement.

Cultural Weed Control. Control of weeds in this crop is one of the major problems in its production during the early stages of its growth. Cultivation by machinery is hampered by the necessity of the plants spreading between rows. Improved cultural and possible chemical methods of control are essential.

Plant Breeding with Phormium. This crop should be studied from the point of view of developing varieties adapted to United States climate and machine methods of handling.

630.7
Un37re
v.27
cop.2

Q.

Restricted

REPORT ON RESEARCH, SERVICE, AND MARKETING EDUCATIONAL WORK
IN THE UNITED STATES DEPARTMENT OF AGRICULTURE

Part II - Chapter 7
Dry Beans and Peas

Prepared at the request of the
House Committee on Agriculture
Special Subcommittee
Honorable Stephen Pace, Chairman

United States Department of Agriculture
Washington, D.C.--November 1950

Table of Contents

Page

FOREWORD
DRY BEANS AND PEAS

A - Production

Breeding and Disease Investigations

BPISAE-b-4-3-Pea and bean diseases and improvement 7-1

Insects and Insect Problems

BEPQ-I-d-1-Bean insect investigations 7-4
BEPQ-I-d-4-Pea insect investigations 7-8
BEPQ-RM:b-425-Control of curly top disease of beans 7-13
Cross References 7-15

B - Utilization

BAIC-RM:a-67-New industrial uses of dried beans and peas . 7-16
Cross References 7-17

C - Marketing

PMA-RM:c-107-Packaging dry beans, peas, and rice 7-18
Cross References 7-20

Foreword

This chapter includes chiefly statements covering research on dry beans and peas, grouped according to fields of work in the production, utilization and marketing of these commodities. As the table of contents indicates, these statements, more specifically, cover breeding and disease investigations, insect problems, and certain phases of research in the use and marketing of dry beans and peas. Cross references at the end of each main section of the statements provide leads to other closely related work.

Chapter 7 is part of a broad report on USDA research, service, and marketing educational work. A portion of such activities conducted by State Agricultural Experiment Stations, State Extension Services, and State Departments of Agriculture and Bureaus of Markets are also included. Readers will find in Part I of the report a summary of significant accomplishments in research and related work.

General Comment

The research, service, and marketing educational activities covered herein are reported for the most part on the basis of "work projects," the level at which various U. S. Department of Agriculture agencies keep separate financial records and prepare separate annual progress reports. The statements for these work projects give pertinent information on the nature and purpose of the work being carried on and on the currently active "line projects," which are subdivisions of activity under the broader work projects. They also cover the history and development of the work, the Federal funds (and in a few instances the State funds) expended, some of the accomplishments, and some of the additional work needed in the areas covered by the work project.

Much of the work reported in this and other chapters of the over-all report is conducted in close cooperation with State agencies. While Federal-State cooperation is indicated for all such projects, it has not been feasible to report in detail the extent and nature of such cooperation. Also, except in specific types of work, no effort has been made to indicate the contributions of cooperating State agencies from the standpoint of accomplishments even though in many instances such contributions have been very important.

It should also be pointed out that the material in the over-all report has been organized, as far as possible, for the convenience of members of the Congress, members of commodity and functional advisory committees under the Research and Marketing Act, and others who are especially interested in specific segments of research, service, or marketing educational work.

Abbreviations of Agency Names

The numbering system used throughout this report includes the initials of the Department agency conducting or supervising the work, as follows:

ARA	Agricultural Research Administration
BAI	Bureau of Animal Industry
BAIC	Bureau of Agricultural and Industrial Chemistry
BDI	Bureau of Dairy Industry
BEPQ. . . .	Bureau of Entomology and Plant Quarantine
BHNHE . . .	Bureau of Human Nutrition and Home Economics
BPISAE . .	Bureau of Plant Industry, Soils, and Agricultural Engineering
OES	Office of Experiment Stations
BAE	Bureau of Agricultural Economics
CEA	Commodity Exchange Authority
EXT	Extension Service
FCA	Farm Credit Administration
FS	Forest Service
OFAR.	Office of Foreign Agricultural Relations
OI	Office of Information
PMA	Production and Marketing Administration
SCS	Soil Conservation Service

PEA AND BEAN DISEASES AND IMPROVEMENT
(BPISAE - b-4-3 - Federal-State-Regular Funds)

A. Purpose and Nature of Current Work

To (1) determine the nature and behavior of the agents causing diseases of peas and beans, and (2) develop methods of eliminating or reducing field and market losses from diseases. Basic work on the fungus, bacteria, virus, or other cause of disorder is followed by efforts at control. Spraying, dusting, and seed treatment with chemicals, breeding for resistance, cultural management, cropping systems, and other measures are used.

B. Currently Active Line Projects

b-4-3-1. Diseases of snap beans including identification of fungi, bacteria, and viruses together with their races or variants, occurrence, etc. To find out the nature and habits of the agents that cause diseases in order to help develop ways of avoiding or controlling them.

b-4-3-2. Breeding of improved disease-resistant snap bean varieties. To develop varieties of snap beans that will resist specific diseases and therefore produce higher yields and better quality than those now available.

b-4-3-3. The development of bean disease control methods other than breeding. Pending the development of resistant varieties, to develop improved disease-control measures such as spraying or dusting with fungicides, chemical seed treatment, special cultural methods, field or soil management, and cropping systems.

b-4-3-4. Control of lima bean diseases by breeding. Objectives are the same as for snap bean in b-4-3-2 above.

b-4-3-5. Breeding curly-top resistant beans. Objectives are the same as for b-4-3-2 above, except that they are directed primarily to developing curly-top resistant snap beans suitable for commercial culture in those western areas where curly-top causes serious losses or prevents successful culture.

C. History and Evolution of This Work

Studies of the nature and efforts to control pea and bean diseases go back to the early 1900's. Prior to 1930 major emphasis was on the nature of the fungi and bacteria that attacked these crops, and on chemical, cultural and other artificial means of control. During the past 20 years increasing amounts of work have been done on the numerous virus diseases that affect beans and peas and the breeding of resistant varieties has become the most desirable method of disease control. The frequent appearance of entirely new forms of virus and rust compels continuous study and experimentation to hold losses down. In the program of breeding for disease resistance, selection is also made for improvements in yield and quality. The seed processing, market garden, and dry pea and bean industries depend to an increasing degree upon the technical guidance and accomplishments afforded by this work because of the increasing complexity and difficulty of problems of maintaining yield and quality.

D. Funds - Annual Expenditures

Realignments of work and changes in organization in the past 30 years make accurate estimates of expenditures in the earlier years impracticable. Expenditures during the 1920's probably did not exceed $20,000 a year; during the 1930's they ranged up to $35,000 to $40,000 and during the 1940's up to $65,000 to $76,430 in 1950.

E. Examples of Outstanding Accomplishments

Disease-free seed. Work under the project was instrumental many years ago in guiding the transfer of the seed bean industry from the humid East where seed-borne diseases are prevalent, to the irrigated districts of the West where seed relatively free of certain serious diseases has since been produced — one of the least expensive but most successful disease control measures ever accomplished.

Sulphur to control bean rust. Methods were developed for obtaining a high degree of control of rust on beans at low cost by using dusting sulphur.

Virus diseases of beans and peas. The identity, nature, range of plants harboring them, and other essential facts about a large number of disease-causing viruses have been developed, together with measures for minimizing the losses due to some of them. These technical guides are basic to further controls.

Bean disease monograph. A monographic study of bean diseases and their control, recently published, is the outstanding guide in this field in this country for scientists and bean producers.

Resistance to bean mosaic and other viruses. This project has produced and shared in production of many important mosaic-resistant varieties of snap beans. In addition to the high-quality disease-resistant varieties now grown commercially, others are in course of development that are resistant to less-prevalent viruses which appear to be on the increase. As new viruses appear, resistance is sought and if found the mode of inheritance is determined and resistant breeding stocks developed as soon as possible.

Rust resistant beans. The bean rust problem is somewhat analagous to that of wheat rust, in that many strains exist and new forms arise frequently. Varieties have been produced that are resistant to more than a dozen of the 20-odd forms known.

Curly-top resistant snap bean. The only curly-top resistant snap bean available was produced a few years ago. Other new sorts much superior in quality to the first one are now under commercial test and one or more probably will be released soon.

Superior lima beans. Although not resistant to disease, several lima beans of superior yielding ability, high quality, and tolerance to adverse conditions have been released in the past 10 years. One of these has attained major importance and all are grown commercially.

F. Some Additional Work Needed

Development and evaluation of inter-species beans. No resistance to certain diseases has been found in common field and snap beans or lima beans, but may be available in other species. Studies of disease reactions among related species are needed with a view to attempting inter-species crosses, for which special methods will probably have to be developed.

BEAN INSECT INVESTIGATIONS

(BEPQ No. I-d-1 - Federal-State-Regular Funds.)

A. Purpose and Nature of Current Work

The purpose of this work is to develop and improve insecticides to control, effectively and at a low cost, the bean pests which occur commonly in the eastern coastal region, such as the Mexican bean beetle, corn earworm, potato leafhopper, two-spotted spider mite, bean leaf beetle, thrips, bean looper, and clover leafworm. Currently, work is under way to devise methods for the control of each of these pests when they occur alone, or when two or more of them are attacking the bean crop at the same time. In addition, information is being obtained on the most effective time of application of each of the insecticides tested. Especial consideration is being given to the avoidance of harmful insecticide residues on the market product in the development of remedies and spray schedules, and to the effect of each of the materials on the plants, on the soil, and on the operator.

B. Currently Active Line Projects

I-d-1-1 - All-purpose insecticides for bean pests. To develop an insecticide, or combination of insecticides, that will control the principal insects and related pests, such as spider mites, that damage the foliage and pods of beans.

I-d-1-2 - Schedules of treatment for bean pests of long-season bean crops. To determine the most effective schedule of application of insecticides for the control of insects and related pests on pole beans.

C. History and Evolution of This Work

Research on the control of insects affecting beans became a large-scale project when the Mexican bean beetle started to devastate bean fields in the east in 1920.

This insect, known as a minor pest of beans for many years in Colorado and New Mexico, made its appearance in outbreak numbers in Alabama. It soon became evident that this outbreak constituted a menace to the bean crop of the eastern states. Control of the Mexican bean beetle was the only hope of home gardeners and commercial growers continuing to produce beans successfully. The insect spread rapidly. Within a period of 10 years it had caused damage over most of the eastern states. It is still the major pest of beans in most eastern states. In 1946 an outbreak occurred in southern California, which still has not been stamped out.

To prevent loss of crops from this pest, large-scale testing of insecticides was started in 1921. Parasites and predators were sought in Mexico, the original home of the beetle. Laboratory headquarters were established at different points as the pest spread to test the control remedies under different bean-growing conditions.

The insect feeds on the foliage throughout the season, so the problem involved the development of a control schedule that would protect the crop and not leave a poisonous residue of insecticide on the bean pods. Calcium arsenate at first was an acceptable remedy when applied before the pods set. Calcium arsenate did not remain acceptable, however, since it caused serious injury to the bean crop under certain weather or climatic conditions and with different types of calcium arsenate. Magnesium arsenate was then developed as a specific remedy to meet the situation, but poisonous residue was as great as with calcium arsenate. Pyrethrum, a nonpoisonous material, was too expensive for general use. Many compounds were tested during the course of the investigation, including all the arsenicals, several fluorine compounds, and the barium salts - even Epsom salts. DDT is not effective against the bean beetle. Even mechanical means of collecting the beetles or knocking them from the plants were also tested.

The best control of the Mexican bean beetle as a pest of the snap-bean crop was the development of rotenone insecticides through the use of ground roots of derris and cube as sprays or dusts. These materials have little residual action and are not very effective against other bean pests.

Funds during the first year of the insect's occurrence in the east were appropriated for quarantine against the insect. It was soon recognized that its spread could not be stopped because the pest is a ready flyer even in the presence of food. The money appropriated for this purpose was returned to the United States Treasury.

It became obvious during the course of these investigations on the bean beetle that other insects, such as the corn earworm, potato leafhopper, and the two-spotted spider mite and others, also claim a heavy annual toll from the bean crop. The work on the bean beetle has been curtailed during recent years and emphasis placed upon the development of satisfactory remedies for the control of the other bean insects. Newer insecticides are being tested extensively against all these pests.

D. Funds - Annual Expenditures

Approximate annual expenditures for successive 5-year periods were: $33,000 for 1921-25, $34,000 for 1926-30, $41,000 for 1931-35, $27,000 for 1936-40, $7,000 for 1941-45, and $7,000 for 1946-50. Expenditures in 1950, $7,000.

E. Examples of Outstanding Accomplishments

Rotenone insecticides developed for control of Mexican bean beetle. A highly successful remedy for the control of the Mexican bean beetle was developed, consisting of spraying or dusting with an insecticide prepared from the ground roots of two tropical plants known to the trade as derris and cube, which contain rotenone. This remedy, with directions as to its use, was made available to the public by means of a Farmers' Bulletin.

The discovery that rotenone in minute quantities controlled the Mexican bean beetle was of particular importance to the green bean or snap bean growers. Dosages of the insecticide sufficient to control the pest left no deposit on the bean pod or foliage that was detrimental to the consumer, man or beast. The general use of this material instead of arsenicals removed the health hazard risk to the consumer and the possibility of a grower's product being condemned when marketed because of poison spray or dust deposits. During World War II an amount of rotenone insecticides was used which was sufficient to treat 240,000 acres of beans. This discovery led to other fields of research, which resulted in the widespread use of rotenone insecticides on leaf vegetables and some fruits.

Experiments against the Mexican bean beetle showed for the first time that various types of calcium arsenate insecticides caused different effects on plants and insects, resulting in material savings to growers, and to manufacturers of these products.

Magnesium arsenate was developed as a remedy for the Mexican bean beetle in these experiments.

"Hopperburn" controlled. It was shown from this research that hopperburn, a bean disease which is caused by the potato leafhopper, could be controlled by treating the crop with bordeaux mixture. A sulfur-pyrethrum dust was also shown to be effective against the potato leafhopper, a serious pest of beans in the early-producing areas of the southeast.

Demonstrated rotenone insecticides impart to the bean plant some substance by absorption which discourages feeding of the Mexican bean beetle.

Rotenone insecticides' effectiveness increased by addition of oil and synergists. It was demonstrated that the addition of small quantities of either mineral or vegetable oil to rotenone insecticides increased their value as insect killers. The addition of synergists known as piperonyls increased the insecticidal action of low rotenone content dust mixtures, thereby reducing cost of rotenone.

Cryolite developed as a control for corn earworm. Cryolite was shown to be effective against the corn earworm on bush lima beans.

Dual-purpose remedy successful in Coastal region for several bean pests. A dust combination containing rotenone, DDT, and sulfur has been successful for the control of such pests as the two-spotted spider mite, corn earworm, and Mexican bean beetle when attacking the crop at the same time.

Equipment improved for applying insecticide dust to beans. A scoop nozzle was developed for applying insecticides to the underside of bean leaves from power machines.

F. Some Additional Work Needed:

Investigations on aphids, red spider mites, and thrips as carriers of diseases on beans needed. Several species of aphids and thrips are known to be carriers of various diseases affecting beans. This problem is especially critical on beans grown for seed. It is suspected that other species of insects and related forms, such as red spider mites, may also be responsible for starting and spreading diseases of beans. There is urgent need to determine, in cooperation with plant pathologists, which of the species of insects or spider mites occurring on beans act as carriers of disease and to develop methods for the control of the responsible species.

Control measures needed for the lima-bean pod borer. Investigations conducted during the period 1931-1943 yielded much necessary information on the habits of the lima-bean pod borer, and showed that cryolite is fairly effective against this insect. There is a critical need for reopening these investigations to determine the value of the newer insecticides in combating this pest. The lima-bean pod borer has caused serious damage in lima bean fields of southern California during recent years.

Bean cutworm control method needed. The bean cutworm has caused serious damage to the growing bean crop during recent years. It also damages the partly mature beans after they are stacked or windrowed. It is of particular importance on the sandy soils of Idaho and Colorado.

Lygus bug control method needed. Lygus bugs have been causing injury to the foliage and seeds of lima beans for several years in southern California. They cause pitting and malformation of the bean seed. This results in material loss in yield and quality. An investigation is required to find a safe, effective insecticide for Lygus bug control as well as the most effective time of its application and its effect on the bean crop.

Seed-corn maggot control method needed. The seed-corn maggot is a serious pest of beans wherever this crop is grown. It has caused extensive losses to the bean crop in New York, Michigan, and California in recent years. There is no satisfactory control measure known for this pest. Time of planting, planting of a surplus of seed, soil condition, and fertilization have brought some measure of control. An effective seed treatment is needed as a solution to the problem.

Cowpea curculio control method needed. The cowpea curculio is a serious pest of blackeyed peas grown for human consumption. It infests the edible seeds and not only renders infested seeds unfit for human food but also incurs the risk of seizure by health authorities because of its contamination of the canned product. No satisfactory control for this pest has been devised and little or no work on this problem, which has limited the supply of canned "blackeyes" from the south, has been done.

PEA INSECT INVESTIGATIONS
(BEPQ - No. I-d-4 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to discover and develop the most effective and economical insecticide treatment for the control of insects attacking peas. Currently, the major emphasis is on the pea weevil and the pea aphid on the green pea and the weevil on the dry pea crops.

The current research is designed to obtain information on the most effective time of application of each of the insecticides tested and the best equipment to use in applying the insecticides and to determine important facts regarding the habits of these insects that are needed for the development and application of control measures. In the development of remedies and insecticide application schedules especial consideration is given to the avoidance of harmful insecticide residues on the marketed product, and to the effect of each of the materials on the plants, on the soil, and on the operator. Where pea vines are destined for use as feed for dairy animals or animals being finished for slaughter, consideration is given as to whether the insecticides applied to the growing crop will remain on the harvested vines to such an extent as to contaminate milk products and meat.

B. Currently Active Line Projects

I-d-4-1 - Evaluation of DDT and other new insecticides for pea weevil and pea aphid control in the west. To develop, under conditions existing in the west, a schedule of insecticidal control of the pea weevil and the pea aphid by use of materials which give an effective and economical control and will not cause a health hazard.

I-d-4-2 - Methods of applying insecticides for pea weevil and pea aphid control. To compare the relative effectiveness of various types of ground equipment, including such equipment as hand-operated and power-operated dusters and sprayers, mist blowers, aerosol dispensers, and various types of aircraft, in applying insecticides for pea weevil and pea aphid control.

I-d-4-3 - Criteria as to the need for and economy of pea weevil control measures. To determine by experimentation the number of pea weevils in pea fields grown for canning or other processing, and in pea fields grown for dry seed, that constitute a serious danger to the pea crop from the standpoint of weevil infestation in the harvested peas, and consequently require insecticide applications.

I-d-4-5 - Evaluation of DDT and other new insecticides for pea aphid control (in the east). To develop, under conditions existing in the east, a schedule of insecticidal control of the pea aphid by use of materials which give an effective and economical control of this insect and will not cause a health hazard.

I-d-4-7 - Ecology of the pea aphid. To study the pea aphid problem under dry-land conditions in Washington and Oregon to determine the relation between reduction in yield of the pea crop caused by the pea aphid, by pea diseases, and by unfavorable weather, respectively. Also to obtain information on the habits of the pea aphid that will aid in the most effective timing of insecticide applications.

C. History and Evolution of this Work

There are two widespread pests of importance which affect the production of peas, namely, the pea aphid and the pea weevil. The pea aphid is a universal pest of peas and also attacks clovers, alfalfas, and other legumes. It maintains itself by sucking the plant sap. Yield and quality are reduced by its direct feeding and indirectly crop loss occurs from plant diseases it transmits.

The first outbreak of the pea aphid occurred on the Atlantic Coast in 1899, causing a crop loss that year of $3,000,000. It remains a pest of annual importance in one pea-growing area or another in the United States. Through the demand of canning interests and pea growers, an investigation to develop methods of combating the pea aphid on the cannery crop was started in 1923 with headquarters at Madison, Wis. From 1916 to 1927 studies in a limited way were conducted on the biology and control of this pest in California on the crop grown for the green market. Prior to this period the studies on this pest were confined to the small-scale control tests with kerosene emulsion and nicotine as insecticides and mechanical devices to kill the aphid in Maryland and Virginia. This work has continued, the emphasis of the investigation being placed on the development of an effective economical control of the aphid. Insecticides prepared from a wide range of chemicals were tested in the dust, spray, and aerosol forms, together with the testing of different types of machines for applying an effective dosage of the insecticide. Mechanical devices for collecting the aphids were designed and tested.

Accompanying the increase of the pea acreage for processing in Washington and Oregon, outbreaks of the aphid occurred to plague the new industry and, with financial aid from the Northwest Canners Association, an investigation on the control of the aphid under the conditions obtaining in that area was commenced in 1947.

During the course of these investigations several remedies have been developed which have brought a measure of relief to the grower and canner. From the early days of the use of nicotine as a remedy, followed by rotenone dust, and, currently, with DDT and parathion, the degree of control exerted on the aphid has varied with the season and with the region. To keep the grower in all of the pea-growing states currently informed as to the results of the research, special conferences were held each year with the State workers and special bulletins issued on the latest findings as to the most effective control and the period during which the crop should be treated. Pea canners in most areas now are prepared to apply insecticides or have them applied by the use of ground machines or airplanes as a result of this work. A liaison service on aphid conditions is maintained between State and federal agencies and canning organizations. The importance of timeliness of application has been recognized and the canners have trained personnel who survey the pea fields for aphid infestations. During 1948 and 1949, a total of 166,000 acres of peas were treated in Wisconsin at an average cost for material alone of $3.75 per acre.

The pea weevil feeds within the developing pea in the pod. Infested peas are about two-thirds weevil grub at harvesttime and are of no value for sale as food for man. Infested green peas, canned or quick-frozen, have been declared unfit for human consumption by health authorities.

The production of seed and dry peas was practically abandoned in the eastern areas because of the pea weevil. In the early '20's a new industry in dry pea production was started in the northwest. The concentration of dry pea production in this area produced a pea weevil problem similar to that which occurred in the eastern states.

An investigation was started in 1930 to develop a method for the control of the pea weevil as a pest of dry peas. The work was expanded in 1936 to include the control of the pest in green peas grown for canning or processing. The peas produced in the Oregon-Washington area were of a particularly high quality and the discovery that the processed product was contaminated with weevil grubs was a near-fatal blow to this new industry. To save the industry, early control of the weevil was essential. Through combined efforts of State and federal entomologists, aided financially and otherwise by the Northwest Canners' Association, a method had been worked out within a period of 3 years which was satisfactory. Its success depended upon timeliness of application of the insecticide.

D. Funds - Annual Expenditures

Annual expenditures have been fairly constant except for material increases in the fiscal years 1925, 1931, 1938, and 1948. They averaged about $3,000 from 1916 to 1924, $8,000 from 1925 to 1930, $19,000 from 1931 to 1937, and $33,000 from 1938 to 1947. Expenditures were approximately $52,000 in 1948, $55,000 in 1949, and $48,000 in 1950.

E. Examples of Outstanding Accomplishments

Tested insecticides and developed formulae that will give practical control of the pea aphid. During the course of these investigations, nicotine sprays and nicotine dusts were developed which gave control of the pea aphid under certain conditions. Rotenone insecticides, particularly in the dust form, with a special form of talc, were more effective under adverse weather conditions than the nicotine preparations. DDT insecticides were developed and applied with success as dusts, sprays (emulsions and wettable powders) and aerosols. However, the durability of DDT introduced a factor of undesirable residues on the pea vines used as ensilage for milk animals. Normal feeding of such ensilage resulted in traces of DDT being secreted with the milk. This hazard was largely overcome by the timing of applications and reduction in the amounts of DDT used per acre in treating for pea aphid. Parathion, one of the latest materials used as an insecticide, has yielded excellent results against the pea aphid. In the dust or spray form used in dosages fatal to the aphid, parathion leaves no dangerous residue on the pea vines. However, its immediate effect on man and animals is such that extreme caution must be exercised in treating pea fields to prevent accidental poisoning of the operators of spraying or dusting equipment.

Developed and improved equipment for application of insecticides which resulted in more effective control of pea aphid. Experimental work has shown that weather conditions at the time of application of the insecticides affected results and that wind was the most important factor when dusts were used. A trailer or apron has been devised that, when attached to the dusting machine, results in effective application in wind movements up to 10 to 12 miles per hour. Unequal output of dust from the nozzles of the duster and the amount of dust discharge from the duster per acre affects adversely aphid control. These faults have been corrected to a marked extent by manufacturers of equipment accepting the results of our research on more efficient equipment.

The development of sampling methods as an index to the necessity of aphid control has led to a greater protection of the pea canning crop. Research work on infestations of aphid in pea fields by standardizing sampling methods yield information on aphid populations in relation to crop damage that leads to more effective crop protection from both the standpoint of quality and yield. Canners have adopted the sweeping with an insect net method developed for sampling of pea fields and as a result start control operations before the aphid damage gets under way. During the course of these investigations a self-recording rain and wind gauge device which needs attention only weekly was developed. From its use valuable data was obtained on the effect of weather on aphid development and control operations.

Developed control for the pea weevil. This pest of long standing is now controlled and no longer a threat to the pea-processing and canning industry of the northwest. The development of the rotenone insecticides and the demonstration of methods of its application to the pea crop grown for canning or quick-freeze purposes has eliminated the pea weevil as a threat to the successful production of green peas in the west. Efficacy of remedies is attested to by the fact that in 1938 the frosted food industry was on the verge of abandoning the quick-freezing of peas in Oregon. Today a large number of quick-freeze pea processors have been established in the pea weevil-infested areas of Washington, Oregon, Utah, and Idaho.

Determined that knowledge of time of weevil emergence from winter quarters and the number of weevils per acre in pea fields was essential to adequate control of the pea weevil. The relation of the number of adult weevils per acre to the number of infested peas at harvesttime has been established and a dependable sampling method has been developed, which consists of sweeping blossoming peas with a hand net at the borders of the field for the presence of overwintering weevils. This method is being generally used by canners' field men as a means of determining which fields are in need of treatment with the insecticide to prevent weevil contamination of the harvested product.

Developed a high-powered duster equipped with a box-like trailer extended to cover 40 feet in one run across the pea fields which aids in a rapid and effective application of the insecticide. This development was of especial importance in the large pea-growing areas where time is a deciding factor between adequate and inadequate control of the pea weevil.

DDT proved effective as a pea weevil killer. DDT in dust formulations was shown to be very effective against the pea weevil, but its use

LIBRARY
UNIVERSITY OF ILLINOIS

leaves undesirable residues on pea foliage. However, this material has been used extensively on the dry pea acreage for weevil control where the pea vines are not used as forage for dairy cattle.

Methoxychlor demonstrated as a possible substitute for rotenone insecticides. Three years' results with methoxychlor have shown it to be as effective against the pea weevil as rotenone and DDT and the indications are that the residues which are left on the vine will be of little consequence. The material apparently deteriorates rapidly under atmospheric conditions.

F. Some Additional Work Needed.

In addition to the current research there is an immediate need for: Investigations of aphids and other insects as carriers of diseases on peas. Several species of aphids are known to be carriers of various plant diseases affecting peas. It is suspected that other species of insects, such as thrips, leafhoppers, and related forms, such as red spider mites, may also be responsible for starting and spreading diseases of peas. There is urgent need to determine, in cooperation with plant pathologists, which of the species of insects or spider mites occurring on peas may act as carriers of disease and to develop methods for the control of the responsible species.

Investigations on the pea moth, a pest of potential importance to the whole pea industry in the northwest and northern Wisconsin. This insect has limited the production of dried peas in Snohomish and Skagit counties of Washington. To prevent damage to the green pea crop, State regulations prohibit the growing of dry peas in these counties. A study of this insect and measures for its control is needed to protect other pea-growing areas if and when it spreads.

CONTROL OF THE BEET LEAFHOPPER (WHITEFLY) AS THE CARRIER OF VIRUS OF CURLY TOP DISEASE TO BEANS

(BEPQ - No. RM:b-425 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to determine if control of beet leafhoppers as carriers of curly top disease to beans grown for seed in southern Idaho can be accomplished by killing the insect on weeds in the range and desert areas and on abandoned and burnt-over land. Eighty percent of the seed for the production of green beans grown for canning and freezing and the fresh market are produced in southern Idaho.

The nature of the current work consists of: a pre-determination of the most likely areas to carry significant populations of the leafhopper over winter, which then will be kept under observation. When the leafhopper becomes active and weather conditions favorable in the spring, the weed growth supporting the leafhoppers will be sprayed with a DDT preparation. In any event, the spray will be applied before the leafhoppers start to move into cultivated areas. Comparative counts of the leafhopper before and after treatment yield the percentage of kill of the insect. Later, the occurrence of curly top in the bean fields will be recorded and these data compared with leafhopper and curly top conditions of the previous 15 years. Experiments will be conducted with different types of applicators and killing agents. No materials will be used that are detrimental to range stock or cultivated crops.

B. Currently Active Line Projects

RM:b-425-1 - Seasonal survey to determine abundance and distribution of beet leafhopper and its wild host plants in southern Idaho. Surveys are made in the late summer, fall, and spring and the important breeding areas mapped to aid in the application of insecticides. These areas are continually shifting and changing in importance.

RM:b-425-2 - Development of a more efficient insecticide for beet leafhopper control in wild host areas under unfavorable climatic conditions. Insecticide applications must begin in early spring when at times 10 or 15 percent of the insects survive the best available treatments. Attempts are being made to improve the insecticide mixture.

RM:b-425-3 - Development of effective methods of applying insecticides to beet leafhopper-infested breeding grounds. Tests will be made of such types of equipment as turbine blowers, vaporizers, conventional power dusters or sprayers, and aircraft sprayers and dusters.

RM:b-425-4 - Evaluation of spraying desert weed hosts of beet leafhopper. To determine if the seed crop of beans in Idaho can be protected from curly top disease by insecticides applied to the breeding areas of the leafhopper.

C. History and Evolution of This Work

Surveys have been made of the breeding areas of the beet leafhopper in southern Idaho each year since about 1930 under Work Project I-d-10. These surveys indicated the feasibility of controlling the beet leafhopper in the weed hosts, in the cultivated areas, and in nearby desert breeding areas before the leafhopper moves to the bean fields where control measures have not been successful. Work was begun in 1949 to develop equipment suitable for spraying these areas with insecticides. Tests were made of turbine blowers and an airplane sprayer. The effectiveness of pyrethrum-in-oil was compared with DDT sprays. An attempt was also made in 1949 to control the leafhopper in the breeding areas nearest the bean fields to decrease the number of leafhoppers that reach these fields with virus of the curly top disease. These control operations were greatly expanded in 1950. Studies were also begun in 1949 to develop a method of measuring the value of these control operations in protecting the bean crop from curly top disease.

D. Funds - Annual Expenditures

Expenditures were about $39,000 in 1949 and $37,500 in 1950.

E. Examples of Outstanding Accomplishments

Demonstrated that beet leafhoppers could be killed in desert breeding areas. Turbine blowers were equipped with 4-gallon-per minute hydraulic pumps and USDA air broadcast nozzles and mounted on high-powered trucks. An average of 92 percent of the leafhoppers were killed in 2,625 acres of weeds in the spring of 1949, with this equipment, applying pyrethrum-in-oil. Three of these machines were used in the spring of 1950 to spray 14,925 acres of weeds with DDT emulsion. An average of 94 percent of the leafhoppers were killed. It was also shown that the leafhoppers could be killed with DDT spray applied by aircraft.

F. Some Additional Work Needed

Larger acreage should be sprayed. In addition to current research, the breeding areas of the leafhopper in southern Idaho greatly increased from 1948 to 1950 because of the spread of Russian-thistle to large areas that were burned over during World War II. The important Russian-thistle acreage increased from 8,000 acres in 1948 to 80,000 acres in 1950. Plans were to spray about 10,000 acres in 1950 whereas it developed that 45,000 acres or more should have been sprayed. Only the 14,925 acres nearest the bean-growing area could be sprayed with the facilities available.

Surveys should be extended to the Columbia River valley area to determine the feasibility of spraying weed hosts in that area for the control of the leafhopper.

CROSS REFERENCES

For additional information especially pertinent to subjects reported on in this chapter, see also:

BEPQ - I-d-10- Chapter 16a, sugar beet insect investigation.

BEPQ - I-d-11-Chapter 14, wireworms.

BEPQ - I-d-18-Chapter 14, seed-corn maggot.

BPISAE - q-2-2-Chapter 38, plant disease survey.

BPISAE - RM:b-111- Chapter 38, introduction and testing of new plants, etc.

BPISAE - b-4-7-Chapter 14, vegetable production in the Great Plains.

DEVELOPMENT OF NEW AND IMPROVED FOOD, FEED, AND INDUSTRIAL USES FOR DRIED BEANS AND PEAS, AND SPLITS AND CULLS THEREFROM

(BAIC - RM:a-67 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

To develop methods of improving both the initial and keeping qualities of dry beans and peas, and to produce new food and nonfood products from them. The current work is particularly concerned with the keeping and processing qualities of disease-resistant strains of beans, that are being developed by State agricultural experiment stations, and with a search for new food and nonfood uses for dried beans and peas.

B. Currently Active Line Projects

RM:a-67-1 - The effect of composition, storage, age, and processing variables upon the quality of cooked and canned dry beans and peas. To learn how storage temperature, humidity, and atmosphere (nitrogen, oxygen) influence the storage life of beans as determined by changes in their processing quality (texture, flavor, and color of cooked and canned beans); to devise methods for improving the eating quality of processed beans; and to determine processing quality of new varieties of beans in cooperation with a State agricultural experiment station).

RM:a-67-2 - Preparation and characterization of the components of dried peas and beans. To investigate methods of isolation, properties, and uses of the amylose, amylopectin, and protein components of dry beans and peas in order to evaluate their industrial possibilities. Amylose, in particular, which is one type of starch, can be converted into films and other unusual starch products.

*Preparation of new food products from dry beans and peas. To develop desirable new food products from dry beans and peas in order to increase the consumption of these crops.

C. History and Evolution of This Work

The dry bean and pea growers of this country were encouraged to grow much larger quantities of beans during the recent war. For this reason, production is much higher than it was previous to 1940, and larger stocks of beans are carried over from one year to the next. The present research program was initiated in 1948 to find means for increasing utilization both as food and industrial raw material.

In connection with the expansion of the dry-bean industry, new disease-resistant strains of beans are being developed by some of the State agricultural experiment stations. The plant breeders have been interested primarily in disease resistance and productivity, and only recently have the processing qualities of the new disease-resistant strains been considered.

D. Funds - Annual Expenditures

The annual expenditures on this project have been approximately $40,000 for each of the three fiscal years of its existence (1950, 1949 and 1948).

*Line of work for which no symbols have yet been assigned.

E. Examples of Outstanding Accomplishments

Processing qualities of disease-resistant strains of Great Northern beans. Variation in the processing qualities of six strains of Great Northern beans, developed for disease-resistant properties, was shown to be primarily due to differences in the seed coats. Some strains contained more than 50 percent of beans having seed coats that prevented the uptake of water on soaking. This lack of uniformity lowered the processing quality when the beans were treated by the usual commercial canning procedure. A simple method of treatment to overcome this poor processing quality was developed and included in a publication on the processing quality of beans.

F. Some Additional Work Needed

New uses for peas and beans. While progress has been made on the use of peas and beans in the preparation of snack-food items, dried soups, etc., an expansion of the work on new food uses for peas and beans is needed. The RMA Dry Beans and Peas Advisory Committee has emphasized the need for new uses for these commodities, in order to reduce the carry-over stocks. A large lima bean growers' cooperative has recently requested that studies be initiated on the preparation of canned lima bean soup.

CROSS REFERENCES

For additional information especially pertinent to subjects reported on in this chapter, see also:

BAIC - RRL-3-12-Chapter 14, utilization of dried beans.

BHNHE - RM:a-12-Chapter 29, food utilization and preparation.

BHNHE - RM:a-345-Chapter 29, distribution of nutrients in foods.

IMPROVEMENT OF PACKAGING OF DRY BEANS, PEAS, AND RICE
(PMA-RM-c-107 - Federal-RMA Funds)

A. Purpose and Nature of Current Work

To improve consumer acceptance and reduce spoilage and deterioration of dry beans, peas and rice by improving their packaging. Current work includes: (1) determining the most suitable weights and kinds of transparent packaging film now in use for each size of package; (2) determining the kind of film that will best filter out light rays which bleach green and yellow split peas; (3) determining which kinds of film are best for repelling insects and studying methods of treating the film to eliminate insect infestation of beans and rice; (4) improving shipping cartons for dry beans, peas and rice so as to reduce the breakage of transparent film bags during shipment.

B. Currently Active Line Projects

RM-c-107-1 - Preferred types and sizes of dry bean containers.

To determine trade experience in the use of different types and sizes of packages and, through retail tests, determine and make available to the dry edible bean industry and other interested groups information regarding the most suitable types and sizes of packages.

C. History and Evolution of this Work

During the past 8 or 10 years there has been a general shift from bulk to consumer-size packages in the merchandising of many commodities, including dry beans, peas and rice. The trend recently has been away from kraft and solid cartons to cellophane window and all-cellophane packages. Many types and sizes of containers have been used by different packaging firms in different sections of the country. This led to a request from shippers, wholesalers and retailers for studies of the most suitable types and sizes of packages for the economic distribution of beans, peas and rice, and such studies are being carried on under this project.

Transparent packaging films used in automatic bag making, bag filling and bag sealing machinery have not proved satisfactory under all conditions. Information has been requested by dry bean, pea and rice packagers as to the reasons for failure of heat seals and as to the proper handling and storage of packaging film. The optimum moisture content of rice and the humidity of air at the time of packaging are factors in the packaging of rice that affect quality. Rice also checks and discolors, and it is believed that inferior types of film may contribute to these defects. Answers to these problems are being sought through this research.

D. Funds -- Annual Expenditures

Expenditures for this work have been as follows: 1948, $11,450; 1949, $14,900 and 1950, $18,200.

E. Example of Outstanding Accomplishments

The studies showed that sales of packaged dry beans, peas and rice have usually been greater than sales from bulk supplies, and that the quality of the goods sold in transparent film bags was usually higher than that of the bulk stocks. Therefore, if more retailers offered these products in packaged form, market outlets might be expanded. It was found that consumers sometimes mistake a package containing somewhat less than a pound of these products for a full pound package, and there was already a trend toward elimination of packages containing slightly less than a pound; this also might result in better consumer satisfaction. Of value as a guide to the trade were findings that there is a definite trend toward transparent packaging materials and away from solid cartons and kraft packages, probably indicating the consumers' preference. The heat-sealed type of transparent packaging film was preferred in the trade, so as to take advantage of the economies resulting from use of automatic bag making, filling and sealing equipment.

F. Some Additional Work Needed.

Members of the rice industry advisory committee are interested in the development of improved automatic packaging equipment. An improved type of moisture-proof film will be necessary if the automatic heat seal is to be used successfully. More research is needed to develop film that will be satisfactory both from the standpoint of durability and eye appeal and in preventing checking or cracking of rice kernels when exposed to bright light.

The shippers of dry peas are especially interested in determining if slightly colored film would be satisfactory for packaging split and whole peas to prevent bleaching on retail store shelves. Additional cooperative work with the industry is needed to improve packaging materials and techniques for rice, dry beans and similar commodities.

CROSS REFERENCES

BAE-RM:c-163-Chapter 26, costs and margins.

BEPQ - RM:c-156.-Chapter 5, insect damage to stored grains, cereal products, seed stocks.

BPISAE - RM:c-415-Chapter 5, conditioning and storing of grains.

FCA - a-1-8-Chapter 17, cooperative marketing of special crops.

OFAR -RM:c-2- Chapter 23, foreign activities.

PMA - U.S. Grain Standards Act, Chapter 35.

PMA - Development of grades and standards on grain, rice, beans, peas, hay, straw, etc., Chapter 34.

PMA - Administration of U.S. Warehouse Act, Chapter 35.

PMA - Market inspection of rice, hay, beans, peas, hops, and miscellaneous commodities, Chapter 34.

PMA - RM:c-430-Chapter 36, marketing service programs.

Chapter 32 for reports on crop and livestock estimates.

Chapter 33 for commodity market news service.

630.7
Un37re
v.2^6
cop.2

RESTRICTED
For Administrative use only

REPORT ON RESEARCH, SERVICE, AND MARKETING EDUCATIONAL WORK IN THE UNITED STATES DEPARTMENT OF AGRICULTURE

Part II - Chapter 6

Rice

Prepared at the request of the
House Committee on Agriculture
Special Subcommittee
Honorable Stephen Pace, Chairman

United States Department of Agriculture
Washington, D.C.—November 1950

General Comment

The research, service, and marketing educational activities covered herein are reported for the most part on the basis of "work projects," the level at which various U. S. Department of Agriculture agencies keep separate financial records and prepare separate annual progress reports. The statements for these work projects give pertinent information on the nature and purpose of the work being carried on and on the currently active "line projects," which are subdivisions of activity under the broader work projects. They also cover the history and development of the work, the Federal funds (and in a few instances the State funds) expended, some of the accomplishments, and some of the additional work needed in the areas covered by the work project.

Much of the work reported in this and other chapters of the over-all report is conducted in close cooperation with State agencies. While Federal-State cooperation is indicated for all such projects, it has not been feasible to report in detail the extent and nature of such cooperation. Also, except in specific types of work, no effort has been made to indicate the contributions of cooperating State agencies from the standpoint of accomplishments even though in many instances such contributions have been very important.

It should also be pointed out that the material in the over-all report has been organized, as far as possible, for the convenience of members of the Congress, members of commodity and functional advisory committees under the Research and Marketing Act, and others who are especially interested in specific segments of research, service, or marketing educational work.

- - - - -

Abbreviations of Agency Names

The numbering system used throughout this report includes the initials of the Department agency conducting or supervising the work as follows:

ARA.	Agricultural Research Administration
BAI. . . .	Bureau of Animal Industry
BAIC . . .	Bureau of Agricultural and Industrial Chemistry
BDI. . . .	Bureau of Dairy Industry
BEPQ . . .	Bureau of Entomology and Plant Quarantine
BHNHE. . .	Bureau of Human Nutrition and Home Economics
BPISAE . .	Bureau of Plant Industry, Soils, and Agricultural Engineering
OES. . . .	Office of Experiment Stations
BAE.	Bureau of Agricultural Economics
CEA.	Commodity Exchange Authority
EXT.	Extension Service
FCA.	Farm Credit Administration
FS	Forest Service
OFAR	Office of Foreign Agricultural Relations
OI	Office of Information
PMA.	Production and Marketing Administration
SCS.	Soil Conservation Service

Table of Contents

Page

FOREWORD

RICE

A - Production

BPISAE-a-1-6-Production, breeding, disease and quality investigation 6-1

BAE-RM:b-62-Economics of farm mechanization. 6-5

Cross References 6-6

B - Utilization

BAIC-RM:a-21-Rice utilization. 6-7

Cross References 6-9

C - Marketing

PMA-RM:c-245-Rough rice standards. 6-10

BAE-RM:c-31-Consumer preference on rice. 6-12

Cross References 6-13

FOREWORD

This chapter covers research relating primarily to the production, utilization, and marketing of rice. It is part of a more comprehensive report on the research, service, and marketing educational work of the U. S. Department of Agriculture including a part of such work being done by the State Experiment Stations, State Extension Services, and the State Departments of Agriculture and Bureaus of Markets.

Cross references to functional or cross-commodity lines of work pertaining directly or indirectly to rice are included at the end of each of the major production, utilization, and marketing sections of this chapter. Since these references apply to a wide variety of closely related subjects, they are important in obtaining a complete picture of the work on rice. Attention is also called to Part I of the over-all report which summarizes some of the more significant accomplishments of agricultural research, service, and educational work.

RICE PRODUCTION, BREEDING, DISEASE, AND QUALITY INVESTIGATIONS
(BPISAE-a-1-6 - Federal-State--Regular Funds)

A. Purpose and Nature of Current Work

To (1) develop and distribute improved, adapted, stiff-strawed, high yielding, disease-resistant long, medium- and short-grain varieties of rice of good milling and table quality which are well suited for production by present cultural and harvesting practices; (2) determine the best cultural, irrigation, fertilizer, rotation and harvesting practices to use, in order to maintain soil fertility and to produce high yields at minimum expense. The improved varieties must be well suited for harvesting by the combine-drier method. High yields and good milling and table quality are essential in order to retain and possibly expand our domestic and foreign rice markets. Current emphasis is on breeding for improved quality, production, and disease resistance and to develop medium and long-grain types that the markets desire and which will enable growers to spread their planting and harvesting operations.

B. Currently Active Line Projects

a-1-6-1 - Rice culture and harvesting investigations. To determine the best cultural, irrigation, fertilizer, and rotation practices in order to produce maximum yields of high milling and table quality.

a-1-6-2 - Breeding rice for improved adaptation. To develop better adapted early, midseason- and late-maturing stiff-strawed disease-resistant, long-, medium, and short-grain varieties of high yielding capacity, good milling and culinary quality, well suited for harvesting by the combine-drier method.

a-1-6-3 - Improved methods of breeding rice. To develop improved methods of breeding rice, so as to conduct the work more efficiently and thus produce better varieties.

a-1-6-11 - The maintenance of breeding and genetic stocks. To maintain viable breeding and genetic stocks of rice which possess factors for disease resistance, earliness, hardiness, and other desirable characters that by hybridization may be transferred to adapted varieties.

a-1-6-13 - Pure seed supplies of new improved and commercial rice varieties. To purify, increase, and distribute pure seed rice of the principal varieties in order to maintain high yields of good milling and culinary qualities. The demand for good seed rice far exceeds supplies.

a-1-6-16 - The effect of variety and other factors on the food value of rice. To determine the effects of variety, environment, and cultural practices on the composition and food value of rice. Vitamin, milling, and cooking tests provide a check on effects of the different factors.

a-1-6-17 - Control of rice diseases and breeding of resistant varieties. The purpose of these investigations is to develop controls of diseases by seed treatment, breed resistant varieties, develop desirable changes in cultural and cropping practices, and other means of disease control. Work on stem rots, leaf blight, and seedling blight is currently of special importance.

C. History and Evolution of This Work

Development of improved rice varieties was begun in 1899 and was confined largely to the testing of varieties introduced from foreign countries. These introductions were tested on demonstration farms in Louisiana and Texas from 1900 to 1908. The Rice Experiment Station at Crowley, La., was established in 1909. Demonstration tests with rice were started in 1909 in South Carolina, Arkansas and California, and in 1910 in eastern Texas. As a result of these demonstrations, the Rice Experiment Station at Beaumont, Texas, and the Biggs Rice Field Station, Biggs, Calif., were established in 1912. The Rice Branch Experiment Station was established in Arkansas in 1927. In California, rice production was established as a result of demonstrations conducted in that State before commercial production began; whereas in the Southern States rice was an important crop before the rice stations were established. In each State the stations have been responsible for developing improved varieties and better cultural, irrigation, fertilizer and rotation practices. Although the average yield of rice per acre for the period 1940-49 was lower than for the previous decade because of the big expansion of production by new growers and on poorer land, as compared with the 1910-1919 period the average per acre yield in the last decade has increased by 24 percent largely as a result of improvements in varieties and other practices growing out of this research and the shift to mechanized methods.

D. Funds--Annual Expenditures

A rough estimate of annual expenditures for rice investigations from 1909 to 1913 ranged from $3,800 to $9,800; 1913 to 1931 from $9,800 to $40,000; 1931 to 1941 from $40,000 to $43,000; and 1941 to 1950 from $43,000 to $54,000.

E. Examples of Outstanding Accomplishments

Development of improved varieties. The Colusa and Caloro short-grain varieties, which were developed and distributed by the Department, have been the principal commercial varieties grown in California for 30 years. In 1949 these varieties were grown on about 95 percent of the California rice acreage. In recent years in the Southern States a marked shift has occurred in the proportion of the acreage sown to improved high quality long-grain varieties developed and distributed by the rice stations. In 1931, for example, long-grain varieties were grown on only 16 percent of the southern acreage, as compared with 53 percent in 1949.

Varieties developed and distributed by the rice stations were grown on over 90 percent of the rice acreage in 1949. Rough rice of the high-quality, long-grain varieties sells at a higher price than that of the varieties they have largely replaced. On the basis of the 1949 crop these improvements of quality in the new varieties added for this season alone more than 20 million dollars to the growers' income.

Irrigation and weed control. As a result of research, better irrigation practices for weed control are now used. Experiments in California showed that continuous submergence of the rice lands from seeding time until just prior to harvest successfully controls barnyard grasses, the most troublesome weeds in California rice fields. These grasses are effectively controlled by seeding rice broadcast on a well-prepared seedbed and immediately submerging the land, or by first submerging the land and seeding broadcast on the water. Approximately 90 percent of the rice acreage now grown in California is broadcast on the water by airplane. The rice seed germinates beneath the water and the seedlings emerge, whereas barnyard grass seedlings are unable to emerge through the water. This method of irrigation has eliminated hand-weeding and resulted in estimated savings to growers of one-half to 1 million dollars annually. Barnyard grasses are being partially controlled in the Southern States by early submergence of rice fields. On very grassy fields a modification of the continuous submergence method also is being used to advantage.

Fertilizer usage. Experiments to determine the fertilizer requirements of rice at four stations have resulted in fertilizers now being used in larger amounts and to much better advantage. Nitrogen and phosphorus give the largest increases in yields. In Arkansas, California, and Texas, for example, the application of 30 to 80 pounds of nitrogen per acre at the proper time increases yields by 300 to 1,200 pounds.

The development of parboiled rice. The parboiling of rice has long been practiced in certain oriental countries. Those who consume parboiled rice there seldom develop beriberi, whereas heavy consumers of untreated milled rice are commonly afflicted with this disease. The results of preliminary experiments with the parboiling of rice were reported by the Bureau in 1935. The results showed that parboiling increased materially the yield of head (whole kernels) rice in milling; improved the cooking quality, and made it more suitable for use in canned products. Later these results were of assistance to millers in establishing parboiling plants in this country. The parboiled rice produced was largely used by the Armed Services during World War II, and since 1945 it has been generally available.

F. Some Additional Work Needed

Development of hardy (tolerant to cool temperatures) long-grain varieties adapted for growing in California. None of the present commercial varieties of this type can be grown successfully in California because of its low yield and lack of hardiness. If adapted varieties were available, markets for California rice would be enlarged materially.

Development of early, midseason, and late-maturing high quality long-grain rices resistant to new races of the narrow brown leaf spot disease and other diseases that attack Rexoro, Texas Patna, and Bluebonnet--the most important varieties of this grain type--would permit more advantageous use of available labor, as well as harvesting and drying equipment in the production of high-quality rice.

Development of varieties tolerant to saline conditions of the Gulf Coastal area should be feasible, since salt-tolerant types are available in parts of Asia. Salt-tolerant strains adapted to local conditions should be developed by hybridization. Such varieties are needed since in dry years when streams are low, salt water moves up stream to polute the irrigation water and damage the crop and land.

Fundamental studies on the genetics, cytology, physiology, and morphology of rice should receive more attention in order to facilitate improvement by breeding and development of improved cultural practices.

ECONOMICS OF FARM MECHANIZATION AND OTHER IMPROVED TECHNIQUES (RICE)
(BAE - RM-b-62 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

To (1) discover the costs and performance of the newer techniques used in the production of rice and (2) appraise their effects on cost of producing rice and on the organization, operation, and incomes of farms of various sizes. During the early phases of the study, work was concerned with obtaining farm data on different methods of harvesting rice with emphasis on the combine-drier method. The current work deals with the effect of harvesting methods on cost of producing rice and with comparisons of alternative rice-farming systems including varying proportions of cropland in rice and adapted supplemental enterprises that will be most profitable to farmers.

B. Currently Active Line Projects

RM:b-62.4 - Economics of rice mechanization in Arkansas. To ascertain the economic feasibility of the use of newer technological developments in rice production in Arkansas and to determine the most profitable alternative rice-farming systems.

RM:b-62.10 - Economics of rice mechanization in Louisiana. To learn the effect of different methods of production on the cost of producing rice on farms of different sizes and to study the income possibilities of the supplemental enterprises in rice-farming systems in Louisiana.

C. History and Evolution of This Work

Some earlier studies of the organization, operation, and incomes, of rice farms of various sizes were made by the Arkansas, Louisiana, and Texas Agricultural Experiment Stations. Experiments had been made pertaining to rotations, cultural and irrigation practices, and fertilization. But combines and artificial driers have been introduced so recently that no study of the economy of their use had been made until this line of work was initiated, late in 1947, when RMA funds became available.

D. Funds--Annual Expenditures

Estimates of annual expenditures on this project by BAE are as follows: fiscal 1947-48, $6,000; 1948-49, $11,000; 1949-50, $16,000. The Arkansas and Louisiana Agricultural Experiment Stations are cooperating on this study and their contributions of funds about equal those of BAE.

E. Examples of Outstanding Accomplishments

Some facts pertaining to comparative costs in money and labor and to other farm considerations when alternative machines and methods are used in harvesting rice have been ascertained, as well as the relation of income to the proportion of land that is planted to rice. Most farmers cannot afford to learn through trial and error whether an expensive machine or practice will pay although they well know that their investment in harvesting machinery will be much larger if they shift from the binder-thresher to the combine-drier method. It was found that the investment in harvesting equipment on farms having about 200 acres of rice averaged about $20 to $25 per acre of rice, when the combine method was used, and about $8 to $10 with the binder-thresher method. The man labor in harvesting rice with a 12-foot self-propelled combine is about 2½ hours an acre compared with 11 hours when the binder-thresher method is used. The combine increases flexibility in choosing supplemental enterprises in rice farming. Soybeans and lespedeza seed can be harvested satisfactorily with a combine but not with a binder. With the cost-price relationships that have prevailed in recent years the self-propelled combine has an advantage over the binder-thresher method when 120 or more acres of rice (or the equivalent in rice and other crops) are harvested annually. Preliminary analysis of alternative rice-farming systems indicates that, with this cost-price relationship the farming systems with one-third of their cropland in rice and the remaining two-thirds in oats, lespedeza, and soybeans, or combinations of these crops, would be more profitable than systems with half of the land in rice and the other half in supplemental crops.

F. Some Additional Work Needed

Economic appraisals of effects of new techniques. A few Southern rice farmers are using airplanes for seeding, chemical weed control is under way, differentials are paid for different types of rice (i.e., short-grain versus long-grain), and varieties have different yields and they may demand different practices. Then as rice-growing practices and alternative and supplemental enterprises in the Texas areas differ from those in Louisiana and Arkansas, a study somewhat similar to the ones made in Arkansas and Louisiana is needed there. An over-all appraisal of the effects of changing technology on the entire Southern rice area is desirable.

See also Chapter 24, BAE, RM:b-62.

CROSS REFERENCES

For additional information especially pertinent to subjects reported on in this chapter, see also:

BPISAE No. q-2-2, Chapter 38, plant disease survey.
BPISAE No. b-11-2, Chapter 38, introduction and evaluation of rice.
BPISAE No. RM:b-57, Chapter 31, Weed control
BPISAE No. RM:a-111, Chapter 38, Plant exploration and testing.

NEW AND IMPROVED USES FOR RICE AND RICE BYPRODUCTS AND BETTER METHODS OF PROCESSING AND HANDLING RICE

(BAIC - RM:a-21 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

To develop satisfactory methods for the treatment of harvested rice for quali preservation prior to processing, and to develop new and extended uses for ri and its byproducts. The current work includes (1) studies of the methods of handling and processing rice designed to yield improved products and reduce cost of handling and processing; (2) development of new food products from rice and new uses for rice and its byproducts; and (3) investigation of the effect of processing factors on the composition and utility of rice bran oil.

B. Currently Active Line Projects

RM:a-21-1 - Studies in the storage of rice and its component parts. To develop improved methods for storage of brown rice and rice bran to avoid or reduce the losses due to reduction of nutritive value and increase of free fatty acids in these products. Phases of this are conducted in cooperation with the University of California.

RM:a-21-2 - The investigation and control of microbial organisms associated with Southwestern rice to prevent deterioration during storage. To assay the role of microorganisms in the deterioration of rice during harvesting, handlin storage, and processing. To investigate the interrelationships of the enzymes and enzymatic products arising both from the seed and from its microflora. To develop the necessary methods of controlling or retarding microbiological activity leading to deterioration in order to alter and improve the properties and uses of rice and its derived products.

RM:a-21-3 - Investigation of methods of processing on the composition and utility of rice bran oil produced from Southwestern (long and medium grain) rice. To develop methods of processing rice bran for the recovery of oil and methods of processing the crude oil into edible grade products.

RM:a-21-4 - Development of new food products from rice. To develop new, convenient, and attractive forms in which rice can be commercially processed in order to increase its utilization.

RM:a-21-5-(C) - Pilot plant investigations of the effect of drying, storage, and processing factors on the quality of rice. To investigate in a pilot plant the effects of methods of harvesting, drying, chemical treatment, and conditions of rice processing on the yield and marketability of the products. This research is being conducted under contract by the Institute of Science and Technology of the University of Arkansas.

RM:a-21-6 - Isolation and evaluation of antioxidants from rice and rice products other than rice bran oil. To isolate and determine the value of the antioxidant which is present in rice bran, with the objective of developing a new use for rice bran.

RM:a-21-7 - Influence of variety and environment on the composition and processing properties of rice. Through the chemical and physical analysis of several varieties of rice grown at 3 locations for each of 3 years to evaluate the influence of variety and environment on the composition and properties of rice with reference to processing. This work is conducted cooperatively with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

C. History and Evolution of this Work

Research in the Department of Agriculture on the utilization of rice was meager prior to fiscal year 1948. In that year investigations on this crop were started under regular funds of the Bureau and on additional lines of work with allotments from the appropriation for the Research and Marketing Act of 1946. The selection of subjects for research under the Research and Marketing Act was made after consultation with leaders of the rice industry. A program of research on milling and handling of rice was planned after consideration of existing work being done by other state and government agencies. In view of the increasing number of plants producing rice bran oil, research was undertaken to expand its utilization. Development of new food products from rice was undertaken as a means of finding new outlets for the greatly increased rice crop.

D. Funds - Annual Expenditures

During the fiscal years 1948, 1949, and 1950, the period this project has been active, the approximate annual expenditures have been $53,000, $61,000, and $101,000, respectively.

E. Examples of Outstanding Accomplishments

Production of edible quality oil from rice bran has been accomplished. It has been shown that an edible grade oil of unusual stability (resistance to rancidity) can be produced from crude rice bran oil; that the oil can be refined, bleached, and deodorized for use as a cooking and salad oil, winterized (destearinized) for use in the manufacture of mayonnaise and salad dressings, and hydrogenated (hardened) to produce plastic fats of the consistency of shortening and margarine.

Stabilization of rice bran. A method of treating bran to inhibit deterioration (hydrolysis) of the oil in the bran prior to extraction has been develop from the data obtained under this project. The process, consisting of live steam heating and cooling, has been adopted and is in operation in two rice mills.

Stabilization of brown rice. A one-minute steam blanching of undried rough rice has been found to be an effective treatment for stabilizing the grain against development of fatty acids after the hulls are removed. Other methods worked out for accomplishing the same purpose involve the control of the moisture content of the rice and of the storage temperature, or extraction with solvents of the unstable oil present.

New food products from rice. Several new food items from rice have been developed. Rice "curls" are a snack item made from low-cost broken grains of rice. Rice "puffs" are made by immersing the commercial parboiled rice in hot fat or in a current of heated air. Both products are attracting commercial interest because of their attractive taste and texture.

F. Some Additional Work Needed

Crude rice bran oil contains waxes and phosphatides which make refining difficult and result in abnormally high refining losses. Both of these products have considerable potential industrial value, especially the wax, which has been shown to be equal to imported carnauba wax in hardness, bleachability, and other properties. Research is needed to develop methods of separating crude phosphatides and waxes and refining these products.

Microbiology of rough rice. Except for investigations of the plant pathogens, this is practically an unexplored field. Additional work is required on the determination of the identities of the bacteria, yeasts, and molds associated with rough rice deterioration as well as on their physiology, moisture and temperature growth limitations; and to learn which ones, if any, are responsible for discoloration, souring, and heating of rough rice.

Biochemistry of rice. Very little is known regarding the biochemistry of rice. A systematic investigation of the enzyme systems of rice, particularly with regard to their state of activity at different stages of maturation and after different periods of storage, is needed. The part which enzymes play in the heating and discoloration of rough rice, in affecting kernel hardness, and in determining the viscosity, volume, and digestibility differences of cooked milled rice must be determined. Effects of atmosphere of storage and respiration requirements need special attention is seed viability is to be prolonged in storage.

Development of quick-cooking packaged rice. The Rice Advisory Committee has strongly recommended research on production of a satisfactory quick-cooking packaged rice. The standards set for the desired product are that it should cook in not more than 5 minutes and be equal in texture and flavor to freshly cooked white rice.

CROSS REFERENCES

For additional information especially pertinent to subjects reported on in this chapter, see also:

BAIC No. RM:a-556, Chapter 11, fats and oils (stability of rice bran oil)
BAIC No. RRL-5-3, Chapter 38, utilization of rice residues.
BHNHE No. RM:a-13, Chapter 29, Family Food consumption.

REVISION OF RICE STANDARDS TO MEET NEW METHODS OF PRODUCTION, HANDLING, WAREHOUSING, PROCESSING, AND MARKETING

(PMA - RM-c-245 - Federal-RMA Funds)

A. Purpose and Nature of Current Work

To revise the United States standards for rough rice and for milled rice to meet new methods of production, handling, warehousing, processing, and marketing, and to devise equipment necessary for the proper inspection of rough rice and milled rice under the revised standards. Most of the equipment has been built and is being tested. Preliminary standards are being drafted.

B. Currently Active Line Projects

RM-c-245-1 - Revision of rough rice standards.

To develop official standards and methods for the inspection, grading, and certification of rough rice that will reflect milling yield in terms of quality and value, and that will be suitable for use in warehousing, and in sales of and loans on rough rice.

RM-c-245-2 - Revision of milled rice standards.

To develop official standards and methods for the inspection, grading, and certification of milled rice that will be suitable for use in the marketing of milled rice.

C. History and Evolution of this Work

Revision and improvements in the standards for rough rice and milled rice are necessary to keep them abreast of changes in the production, handling, warehousing, processing, and marketing of rice. New varieties and new marketing practices have been developed which created a need for the revision of the standards for milled rice. The rice industry is in urgent need of standards for rough rice that will reflect the quantity and quality of milled rice that can be obtained from a given lot of rough rice.. The work under this project was initiated during the fiscal year 1948. Part of the work has been conducted through a cooperative agreement with an engineering firm.

D. Funds - Annual Expenditure

Expenditures for this work have been as follows: 1948, $7,500; 1949, $11,200; 1950, $17,000.

E. Examples of Outstanding Accomplishments

The Carter Dockage Tester, a mechanical device designed for use in separating dockage and other foreign material from a number of different kinds of grain, has been adapted to remove weed seeds and other foreign material from rough rice. It is very useful in the routine inspection and grading of rough rice.

A laboratory sheller for use in removing the hulls from rough rice has been developed and found to be satisfactory. A laboratory machine for use in completing the milling of rice has been finished, although the correlation of the results of this machine with the results from commercial milling machinery has not been determined. The laboratory sheller and a satisfactory laboratory milling machine will be essential equipment for use in the inspection and grading of rough rice to determine the expected milling yield and the quality of the milled rice produced.

F. Some Additional Work Needed

A correlation of the results from the laboratory milling machine with commercial milling results should be made and, if necessary, modification of the laboratory machine should be made. A machine for separating whole kernels from broken kernels of milled rice should be designed for use in routine inspection work. When new and improved inspection equipment is available, the standards for rough rice and for milled rice should be revised to make them conform more closely with the usages and practices of the rice trade.

LIBRARY
UNIVERSITY OF ILLINOIS

CONSUMER PREFERENCE RESEARCH (RICE)

(BAE-BHNHE-OES-RM-c-31-Federal-State-RMA Funds)

(Related consumer preference research by BAE on other commodities is discussed in other commodity chapters. Consumer preference research conducted by BHNHE and OES, as well as line projects of BAE involving more than one commodity, are discussed in the general statement on consumer preference research in Chapter 26, "Economics of Marketing").

A. Purpose and Nature of Current Work

To find new or greater markets within the United States for the greatly increased domestic production of rice. Rice production in the United States has doubled in the last 15 years, as a result of wartime disruption of rice production and trade in the Orient. If rice producers lose their greatly expanded foreign market, they will suffer losses in income that can be met only by severely curtailing production or finding new outlets in this country. Current research in this project is designed to ascertain consumer preferences for the various types and varieties of rice and rice products, and for different sizes and kinds of packages and for ways of preparing and serving rice.

B. Currently Active Line Projects

RM:c-31.17 - Rice preferences among household consumers To find out what types and varieties of rice and rice products people in the United States like or dislike, what sizes and kinds of packages they prefer, and how they would rather have rice prepared and served.

C. History and Evolution of This Work

Exports of rice from the United States are more than twice as great as they were in 1935-39, because of disruption of production and trade in the Orient. Under this stimulus production has virtually doubled. This project, designed to help stabilize production by finding new domestic outlets, was recommended and given high priority by the RMA Rice Advisory Committee at its meetings in June and December 1947, and June 1948. This survey will complement a study on the export market for rice conducted under another work project.

D. Funds--Annual Expenditures

Consumer preference research on rice undertaken by BAE during the fiscal year 1950 cost $6,500 from RMA funds.

E. Examples of Outstanding Accomplishments

Information useful to the rice producers, processors and distributors is contained in the report just published. Representatives of the rice trade and large food-distributing corporations expressed keen interest in the brief preliminary report issued several months earlier.

F. Some Additional Work Needed

More information is needed on the availability of various forms of rice at retail, according to the RMA Rice Advisory Committee. Use of rice among industrial and institutional consumers and the reasons for their preferences is as important a subject for research to find new outlets as the study of preferences of household consumers already made.

CROSS REFERENCES

For additional information especially pertinent to subjects reported on in this chapter, see also.

BPISAE, BAI, OES, PMA, FCA No. RM:c-415, Chapter 5, methods, equipment, and structures for conditioning of grain, including rice, seeds, and feeds.
CEA-Commodity Exchange Act, Chapter 35.
FCA No. a-1-8, Chapter 17, assistance to cooperatives handling rice.
OFAR, Chapter 23 (especially RM:c-2 and RM:c-544) foreign activities.
PMA, U. S. Grain Standards Act, Chapter 35.
PMA No. RM:c-107, Chapter 5, Improved packaging of rice.
PMA, Development of grades and standards of grain, rice, beans, peas, hay, straw, etc., Chapter 34.
PMA No. RM:c-430, 431, 432, Chapter 36, marketing service programs.
PMA, Market inspection of rice, hay, beans, peas, hops, and miscellaneous commodities, Chapter 34.
Chapter 32 for reports on crop and livestock estimates.
Chapter 33 for commodity market news service.

630.7
Un37re
v.24
cop.2

RESTRICTED
For administrative use only

REPORT ON RESEARCH, SERVICE, AND MARKETING EDUCATIONAL WORK IN THE UNITED STATES DEPARTMENT OF AGRICULTURE

Part II - Chapter 4

Wool and Mohair - Sheep and Goats

Prepared at the request of the
House Committee on Agriculture
Special Subcommittee
Honorable Stephen Pace, Chairman

United States Department of Agriculture
Washington, D.C.--November 1950

General Comment

The research, service, and marketing educational activities covered herein are reported for the most part on the basis of "work projects," the level at which various U. S. Department of Agriculture agencies keep separate financial records and prepare separate annual progress reports. The statements for these work projects give pertinent information on the nature and purpose of the work being carried on and on the currently active "line projects," which are subdivisions of activity under the broader work projects. They also cover the history and development of the work, the Federal funds (and in a few instances the State funds) expended, some of the accomplishments, and some of the additional work needed in the areas covered by the work project.

Much of the work reported in this and other chapters of the over-all report is conducted in close cooperation with State agencies. While Federal-State cooperation is indicated for all such projects, it has not been feasible to report in detail the extent and nature of such cooperation. Also, except in specific types of work, no effort has been made to indicate the contributions of cooperating State agencies from the standpoint of accomplishments even though in many instances such contributions have been very important.

It should also be pointed out that the material in the over-all report has been organized, as far as possible, for the convenience of members of the Congress, members of commodity and functional advisory committees under the Research and Marketing Act, and others who are especially interested in specific segments of research, service, or marketing educational work.

- - - - - -

Abbreviations of Agency Names

The numbering system used throughout this report includes the initials of the Department agency conducting or supervising the work as follows:

ARA.	Agricultural Research Administration
BAI. . . .	Bureau of Animal Industry
BAIC . . .	Bureau of Agricultural and Industrial Chemistry
BDI. . . .	Bureau of Dairy Industry
BEPQ . . .	Bureau of Entomology and Plant Quarantine
BHNHE. . .	Bureau of Human Nutrition and Home Economics
BPISAE . .	Bureau of Plant Industry, Soils, and Agricultural Engineering
OES. . . .	Office of Experiment Stations
BAE.	Bureau of Agricultural Economics
CEA.	Commodity Exchange Authority
EXT.	Extension Service
FCA.	Farm Credit Administration
FS	Forest Service
OFAR	Office of Foreign Agricultural Relations
OI	Office of Information
PMA.	Production and Marketing Administration
SCS.	Soil Conservation Service

Table of Contents

Page

FOREWORD
WOOL AND MOHAIR -- SHEEP AND GOATS

A - Production

Fibers

BAI - b-2-6, Wool and other animal fibers 4-1
BAI - b-8-4, Fur fiber and fur 4-4

Breeding and Genetics

BAI - b-2-1, Sheep breeding investigations 4-7
BAI - b-2-4, Goat breeding 4-11
BAI - b-8-1, Breeding fur animals, including domestic rabbits 4-14
BAI - SRF-2-2, Sheep breeding and improvement in the Southwest 4-17
BAI - SRF-3-6, Sheep breeding and improvement for Western ranges 4-20

Nutrition and Feeding

BAI - b-2-2, Sheep feeding 4-24
BAI - b-2-5, Production and properties of goat's milk . 4-27
BAI - b-8-3, Fur-animal feeding and nutrition 4-29

Management

BAI - b-2-3, Sheep management 4-32

Disease and Parasite Control

BAI - c-5-3, Coccidiosis of sheep, goats, and swine . . 4-35
BAI - c-6-2, Worm parasites of sheep and goats 4-37
BAI - c-9-1, Infectious and non-infectious diseases of fur animals 4-40
BAI - c-9-2, Parasites and parasitic diseases of fur animals 4-42
BAI - RM:b-40, Sheep parasite investigations in Western range states 4-44

Physiology

BAI - b-8-2, Fur animal physiology of reproduction . . . 4-46
BAI - SRF-2-116, Reproduction and lactation in goats . . 4-48

Cross References 4-50

B - Utilization

New and Improved Products and Practices

BAI - b-2-7, Mutton and goat meat 4-51
BAIC - RM:a-141, New and improved uses for wool 4-54
BAIC - RM:a-200, Utilization of wool grease and other wool byproducts 4-56
BAIC - RM:a-372, Improved methods of cleaning and scouring grease wool to yield improved fibers . . 4-58

Table of Contents (continued)

Page

B - Utilization (continued)

Evaluation of Fabrics

BAI - RM:a-427, Developing and evaluating fabrics containing wool of known source and genetic origin 4-60
PMA - RM:c-461, Broadening the use of mohair fiber . . . 4-63

Cross References 4-65

C - Marketing

Market Practices and Services

FCA - a-1-6, Research, service and educational assistance for wool and mohair cooperatives . . . 4-66
PMA - Marketing methods and practices for wool 4-69
PMA, FCA - RM:c-93 and 252, Preparation and processing wool for market 4-73

Grades and Standards

PMA - Development, promulgation, and distribution of wool, wool top, mohair and mohair top standards . . 4-77
PMA - RM:c-359, Improved grades and standards for wool and mohair 4-80

Supply, Demand and Prices

BAE - A-27 and BAE, OES - RM:c-33, Price, supply and consumption analysis for farm products (wool) 4-82
BAE, BHNHE, OES - RM:c-31, Consumer preference (wool) . 4-84

Cross References 4-86

FOREWORD

This chapter is part of a report covering the research, service, and marketing educational work of the USDA. For the purpose of this report "Wool and Mohair--Sheep and Goats" covers activities of the Department relative to sheep and goats, fur and farm fur animals, and the products of these animals.

Included in this chapter are reports on activities dealing with the breeding, feeding, and management of sheep, goats, and fur animals; their protection from diseases and parasites; the handling and processing of their products; the development of new and improved practices for the use of these animals' products; and the problems of marketing and distributing these products.

This chapter also contains reports in part of similar work (or reference to such work) conducted by State Agricultural Experiment Stations, State Extension Services, State Departments of Agriculture, or Bureaus of Markets. Attention is also called to Part I of the over-all report which summarizes significant results of research, service, and educational work in the livestock fields. At the end of each of the production, utilization, and marketing sections of this chapter are cross-references to functional or cross-commodity lines of work pertaining directly or indirectly to wool and mohair, sheep, and goats.

INVESTIGATIONS OF WOOL AND OTHER ANIMAL FIBERS
(BAI - No. b-2-6 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

To determine the physical structure and related properties of wool and other animal fibers, and the influence of breeding, feeding, and mangement on the growth, quality, and manufacturing properties of such fibers. Studies of wool, mohair, and many other fibers used commercially in the manufacture of such products as pillows, mattresses, and upholstery are made in the current work, and analysis of fleeces is conducted to determine fineness, length of staple, crimp, luster, color, structure, and other properties affecting their value for manufacturing use. Spceial study is being made of the effect of breeding and feeding on animals that furnished the fibers.

B. Currently Active Line Projects

b-2-6-6 - Studies of the physical structure and related properties of wool and other animal fibers. To reveal distinguishing characteristics of animal fibers as a basis for their identifications with respect to the genus of animal from which they were obtained.

b-2-6-7 - Studies of the influence of breeding on the quality of animal fibers. To determine the type of breeding **that will result** in the production of the best quality of animal fibers.

b-2-6-8 - Studies of the influence of nutrition on the quality of animal fibers. To determine feeding methods best suited for the production of high-quality animal fibers.

b-2-6-9 - Development of methods of determining physical values in animal fibers. To develop means of determining the structure, diameter, length, strength, elasticity, and felting and spinning properties of animal fibers.

b-2-6-10 - Studies of the manufacturing properties of animal fibers. To determine the effect of breeding, feeding, management, and environment on the manufacturing properties of animal fibers.

b-2-6-11 - Prenatal and postnatal growth of wool and hair. To determine (1) the sequence of growth development in wool and fur fibers; (2) early development of the follicle (the depression from which the fiber grows); and (3) changes in skin thickness and fiber density.

C. History and Evolution of This Work

Until the close of the nineteenth century, wool was the primary reason for the existence of the sheep industry. But since that time the market value of lambs for meat has increased until financial returns for them now are more than for wool. This competition of lamb and wool since the early 1900's increased the need for improvement in fleece **weights** and in qualities most desired by wool manufacturers. To help sheep growers obtain full benefits from their wool, this research project was begun by the Bureau in 1913. Since 1925, the program has been conducted in cooperation with other Federal agencies, and until recent years, with several agricultural experiment stations and some industrial concerns. Improved breeding and management have increased fleece weights in the United States from an average of 2 to about 8 pounds per sheep.

D. Funds--Annual Expenditures

With wool and other animal fiber investigations financed from funds covering work on several lines of research with sheep and goats, estimates in early years are difficult to obtain. Direct expenditures for all sheep and goat husbandry investigations varied from $80,000 in 1923 to about $84,700 in 1934 and averaged slightly over $88,000 annually. During this period there were expenditures for three projects (maintenance of station at Beltsville and fundamental research on animal genetics and nutrition) for which no basis for distribution is available now. The average expenditure for these three projects from 1923 to 1934 was about $92,000 annually. The direct costs for research on wool and other animal fibers varied from about $24,000 in 1935 to about $27,000 in 1943. Emergency funds were made available in 1944 for research on the use of feathers for sleeping bags for the armed forces. Expenditures for this research were about $7,500. Expenditures from regular funds have ranged from about $26,000 in 1944 to $36,400 in 1950.

E. Examples of Outstanding Accomplishments

Development of new devices that make possible more exact knowledge of the characteristics of many important fibers. These instruments, invented originally to seek more precise knowledge of wool, have proved valuable also to industries working with cotton, mohair, bristles, fur, paper, leather, cork, silk, ramie, and dyes. They permit quick, accurate determination of such qualities as fineness, shape, and length of fibers, and distribution of pigment. They greatly aid in selecting suitable fibers for industrial purposes, help breeders of animals and plants that yield natural fibers, and manufacturers of synthetic fibers. Six of these devices were patented for public service. Cost of their development was $5,000 but their value to the textile and other industries is estimated at $4,000,000 annually -- not including their value as an aid to laboratories dealing in crime detection.

Interpretation of the fineness and variability of wool speeded by new technique. As compared with former methods, a much larger number of samples may be analyzed by this method, which consists of short cuts in analysis of photomicrographs, or projected images, of the cross sections of the fibers. Analysis is speeded up from 5 to 10 times and makes quick cataloging practical by wool growers who are making effective use of this method to judge results of selective breeding.

Development of an improved method for revealing surface structures of fur fibers through the use of thermo-plastic film makes it possible to obtain quick impressions efficiently. Such analyses are useful in the wool growing industry, where growers constantly seek fiber improvement, especially for felting purposes.

Salvage of soft part of chicken feathers is made possible by a new technique of removing the quills from the feathers. The feather-fiber material obtained by this process has excellent heat-retaining properties, increases the supply of material used in fabrics that may include short fibers blended with long ones, is used for pillows, and is suitable commercially as an "extender" of down and waterfowl feathers. During World War II research on this problem was performed for the armed forces and results were applied extensively in such equipment as sleeping bags.

F. Some Additional Work Needed

Improvement of wool and hair for greater usefulness in textiles and other animal fiber products. There is urgent need for research on the "handle" or "feel" of wool and hair to reveal variations in the responses of human touch to certain of these fibers. Upon the identification of certain fibers having excellent "handle" qualities there is need of further search for the production factors in genetics, nutrition, and environment that contribute to the excellence of these fibers.

Determination of nutritional and environmental causes of weak or defective wools or hairs is particularly needed by the producers of animal fibers to assist them in reducing to a minimum the growth of unwanted fibers and to aid them in so managing the animals as to produce a maximum of strong and more useful fibers.

Discovery of critical stages in the development of fibers on unborn or suckling animals should provide the foundation for better feeding and management of the dams at these stages, thereby obtaining fibers of greatest usefulness from the offspring.

Microscopic examination of details of the structure of wool fibers, the technique of which has been developed, should be carried further in application to produce proper types of fibers of greatest use in making fabrics and other wool products.

FUR FIBER AND FUR
(BAI - No. b-8-4 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To ascertain the properties of furs of ranch-raised animals, including rabbits, relative to their bearing on the ultimate use by consumers. Current work is directed toward the establishment of objective measurements of quality and the physical characteristics of the fur fibers and skins. Studies also are in progress on factors affecting the growth of furs and fibers to product high-quality skins.

B. Currently Active Line Projects

b-8-4-1 - Development of standards for determining pelt quality. To conduct research on pelts and to establish objective criteria for determining their qualities.

b-8-4-2 - Angora rabbit wool. To analyze the microscopic features of Angora rabbit wool and to relate these findings to mill requirements as well as to home use.

b-8-4-3 - Development of methods of fur investigation. To study the physical characteristics of fur and wool, such as fiber composition, color, and luster as related to quality standards.

b-8-4-5 - Molting in domestic rabbits. To study the environmental factors (feed, season, climate, and age) and the hereditary factors affecting the shedding and the accelerating and retarding of the growth of fibers and to determine the relationship of shedding to new fur growth.

b-8-4-6 - Effects of artificial lighting on the earliness of obtaining prime pelts and on the quality of pelts. To determine the dates for, and the length of time to use, artificial lights on fur animals to produce prime pelts earlier in the season.

C. History and Evolution of This Work

Color and quality of furs materially affect their market value and determine to a large extent the income of fur farmers. To aid farmers in constantly raising the quality of skins, the Bureau's fur-animal research has included studies of the factors affecting these attributes since the initiation of this project in the Bureau of Biological Survey of the Department in 1938. Considerable emphasis was first placed on pattern and curl of skins from Karakul sheep. This entire project was closed out in 1949. As a result of early research, techniques were developed for studying hair structure and the size and distribution of guard hairs and underfur of various types of skins. During World War II, because bristles formerly imported for use in paint brushes were no longer obtainable, the suitability of certain fur animal fibers for this purpose was investigated. In recent years, microscopic study of the wooly characters of rabbits was made and an extensive study of Angora rabbit-wool production was conducted. The development of the pigment of fur fibers, as well as the shedding and new-growth pattern of the fur of foxes and minks, have received the latest emphasis. Currently, studies also are being made on the Pacific Coast of the molting pattern of both Angora and short-haired rabbits. In 1939 all activities of the Bureau of Biological Survey, including fur-animal investigations, were transferred to the Department of the Interior. In 1946 this research was returned to the Department of Agriculture.

D. Funds--Annual Expenditures

Expenditures for this project since its transfer to the Bureau of Animal Industry have been as follows:

Fiscal year 1947 - $18,000
Fiscal year 1948 - 20,000
Fiscal year 1949 - 10,000
Fiscal year 1950 10,300

E. Examples of Outstanding Accomplishments

Determination that a greater proportion of grade No. 1 wool is produced from Angora rabbits if the animals are plucked at the time of molt four times a year than if they are clipped or sheared at those times, or if their wool is harvested by any of these methods every 10 weeks. This finding enables the Angora rabbit breeder to take advantage of the harvesting method that will yield the greatest profits.

Establishment of a method for eliminating undesirable wooly characteristics of fur in meat-type rabbits through selective mating. Microscopic examination and comparison of the size and diameters of cross sections of guard hairs of rabbits indicate clearly the animals having wooly fur, which makes the pelts unsuitable for some types of commercial use. Such animals can be thus eliminated for use in selective matings.

Discovery that grades of fryer rabbit skins are affected very little by climate, season when taken, sex of animal, or grade of carcass. It was found that age of the animal has the greatest effect on quality of rabbit skin. Prices received for domestic skins often determine whether or not domestic rabbit production is profitable.

Determination of the molting and fur-growth pattern of adult minks and foxes. It is now possible by reference to this established pattern to determine whether the fur of these animals is developing properly. Animals with slow and retarded fur growth can then be placed on more nutritional diets to promote the required rate of development.

F. Some Additional Work Needed

New methods for determining and designating color and luster of pelts. Since color and luster are intrinsic features of fur quality, reliable measurements of these characteristics would be of great value in judging and grading furs.

Additional studies relating to effects of season on the fineness of Angora rabbit wool. Fundamental research on the arrangement of fibers in the skin follicles may prove to be a working tool in the selective breeding of Angora rabbits. The spinning quality of the wool is tied up in some way with the number of guard hairs and intermediate guard hairs present and this relationship should be investigated.

Molting and new-fur-growth pattern in Angora and meat and fur rabbits. The quantity of Angora rabbit wool is materially reduced by retarded wool growth, and unprime skins from young rabbits killed for meat are unsuitable for use in the fur trade because of shedding marks and are largely sold to the hat industry at comparatively low prices. A method of eliminating these undesirable traits from the skins will add materially to the income of rabbit growers.

Large-scale investigation of the influence of controlled artificial lighting on the time of obtaining prime skins and color and growth of fur is needed. Small experiments, with limited facilities, have indicated promising results and adequate research might well develop important aids to fur improvement.

SHEEP-BREEDING INVESTIGATIONS
(BAI - No. b-2-1 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

(1) To determine the ability of sheep to produce efficiently high-quality lamb meat, wool, and fur in the various regions of the United States; (2) to locate individuals, families, strains, types, and breeds most efficient for this purpose; (3) to determine the genetic principles that form the basis for improvement, and to introduce the application of these principles into the sheep-breeding industry of the United States. Current work on western ranges is directed toward improvement of white-face types of sheep, and in the north-central and eastern parts of the Nation, of the dark-faced, mutton types. Crosses of these sheep are being tested for better lamb and wool production. Attention is also being given to the development of strains of sheep that will meet the needs of farm regions.

B. Currently Active Line Projects

b-2-1-1 - Selective mating and line breeding of Columbia and Targhee sheep for developing strains suitable to the intermountain range region. To develop and improve sheep of the white-face crossbred type for efficient and profitable lamb and wool production on western ranges.

b-2-1-2 - Selective mating and line breeding of Hampshire, Shropshire, and Southdown sheep for developing improved strains suitable to farming regions. To develop and improve sheep of the dark-face British mutton type for efficient and profitable lamb and wool production on farms.

b-2-1-13 - Crossbreeding purebred sheep of the Hampshire, Shropshire, and Southdown breeds. To determine the relative production of purebred Hampshire, Shropshire, and Southdown sheep and first crosses and three-way crosses derived from mating first-cross ewes with rams of the third crossbreed.

b-2-1-14 - Development of strains of sheep for efficient lamb and wool production in the North Atlantic area. To develop fixed strains of sheep that will efficiently produce high-quality lamb meat and good wool in the North Atlantic area.

b-2-1-15 - Selective mating, line breeding, and crossbreeding Merino sheep. To determine the maximum production of lamb meat combined with the production of fine wool of highest quality that can be obtained from purebred Merino sheep as compared with the production of Merino ewes bred to rams of the Southdown, Shropshire, and Hampshire breeds.

C. History and Evolution of This Work

As the Far West became more settled after pioneer days, and restrictions on unlimited grazing areas forced sheep ranchers into more intensive methods of grazing, feeding, and care of their animals, new problems arose. Because of the need of western sheepmen for new breeds that would produce more meat and wool for a growing market, range sheep investigations were begun by the Bureau in 1906 at Laramie, Wyo. To meet similar needs for improved sheep production on farms, such studies were begun in

1909 at Middlebury, Vt. In the range sheep-breeding research conducted since 1918 at the United States Sheep Experiment Station in Dubois, Idaho, emphasis has been placed on the modification of Rambouillet sheep and the creations of new breeds, such as Columbias and Targhees, that would more efficiently meet the needs of range-sheep producers. Beltsville research on farm sheep began in 1915, and first stress was placed on the production of purebred strains for higher production through selective mating and line breeding. Later, crossing of high-producing strains of various purebred lines was undertaken, and in some cases hybrid lines were interbred for the establishment of new strains. For many years the Bureau has conducted research on the factors affecting reproduction of sheep, but special emphasis has been placed on this work since the mid-thirties.

D. Funds--Annual Expenditures

With sheep breeding investigations financed from funds covering work on several lines of research with sheep and goats, estimates in early years are difficult to obtain. Direct expenditures for all sheep and goat husbandry investigations varied from about $80,000 in 1923 to about $84,700 in 1934 and averaged slightly over $88,000 annually. During this period there were expenditures for three projects (maintenance of station at Beltsville and fundamental research on animal genetics and nutrition) for which no basis for distribution is available now. The average expenditure for these three projects from 1923 to 1934 was about $92,000 annually. The direct costs for sheep breeding investigations under this project varied from about $39,000 in 1935 to about $51,000 in 1943. Expenditures for this project ranged from about $50,000 in 1944 to $85,600 in 1950.

E. Examples of Outstanding Accomplishments

Development of the Columbia and Targhee breeds of sheep resulted directly from experimental work in the Bureau of Animal Industry. These fixed breeds are the product of the selective breeding of crossbred strains of sheep best adapted to the intermountain range region, through the interbreeding of hybrids from breeds having both desirable and undesirable characteristics for the production of lamb meat and wool in this important sheep-producing region. In these new breeds the desirable characteristics of the parent breeds have been preserved and the undesirable traits have largely been eliminated. Seed stocks from the Department's flocks have been distributed to sheep producers, who have found them especially profitable in lamb and wool production. The Columbias are adapted to the rather abundant ranges, and the Targhees to range that is intermediate in availability of forage.

Fixing types and crossing of fixed types of British breeds, such as Southdown, Shropshire, and Hampshire, resulting in superior types of sheep for lamb and wool production on the farm. Selective mating and line breeding of purebred registered sheep from leading flocks in America and Great Britain for about a quarter of a century to fix their excellence for meat and wool production, and then crossbreeding the ewes, resulted in lambs superior to purebred lambs in rate of gain, weight, finish at a given age, and weight of wool per fleece when they reached 1 year of age. Sheep farmers, like corn producers, thus obtain commercial advantages by crossbreeding strains that have been selected and fixed for productive characteristics. Many have adopted this practice.

Creation of a strain of sheep for increased production of wool and lamb meat in the North Atlantic area. Through the combining of the inheritance of the Columbia, Corriedale, and Southdown breeds, the new strain produces heavy fleeces of excellent quality wool at a year's growth, and lambs that grow rapidly and finish readily in the feed lot. Production of this type of sheep promises more profit through the weight of wool and lambs produced on grass than any of the other sheep tested by the Bureau in that region.

Development of smooth-bodied Rambouillet sheep by selective breeding. The Bureau found that, for both lamb meat and wool, sheep of this type were more profitable than those with heavy folds. As a result of these investigations range-sheep producers have changed to smoother type sheep.

Finding a suitable type of sheep for Florida. Native Florida ewes mated with Columbia rams produced lambs that weighed 25 percent more at weaning than those from similar ewes bred to native rams. Moreover, the fleeces of the 1-year-old lambs with Columbia blood weighed twice as much as those of the other lambs. This finding indicates the advantage of the use of the Columbia sire for lamb and wool production in Florida.

Production of desirable Karakul pelts from the crossing of purebred Karakul rams with native mutton breed of ewes. The Bureau found that pelts produced by crossbred lambs having three or four top crosses to purebred Karakul rams were similar in quality to those produced by the better purebred Karakul sheep available in the United States. This information is of especial value to breeders since importation of Karakul stock is prohibited from countries in which foot-and-mouth disease exists.

Development of methods of evaluating semen, by the use of which rams of high fertility can be selected. Methods of staining spermatozoa so that the proportion of live and dead ones in any sample can be determined and the value of the ram as a potential sire can be rated, have been found. These methods are simple enough to be used by the sheepman. He is, therefore, able to recognize good and poor sires before the beginning of the breeding season and, by selection, to increase the lamb production of his flock.

Development and improvement of methods of diluting and storing semen have aided in extending the use of sires in artificial insemination. Dilution of the product permits more ewes to be inseminated from the semen of one ram. For this purpose, egg-yolk-phosphate buffers and modifications of the formula have been extensively studied. Improved methods of storing during shipment permits the semen to be transported long distances.

F. Some Additional Work Needed

Development of fixed strains of sheep especially efficient in the combined production of high-quality and abundant quantity of wool and meat at relatively moderate costs for feed and labor, are essential for future success in American sheep production. Highly efficient individuals appear occasionally, but the establishment of large strains of such highly efficient sheep is yet to be accomplished.

Production of early lambs by out-of-season breeding needs study since such lambs would normally bring the highest prices on the market. In this study, a knowledge of the hormones involved in normal and induced heat in ewes must first be obtained in order to find methods of insuring high fertility in the ewes and the production of normal, healthy lambs.

GOAT BREEDING
(BAI - No. b-2-4 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

To (1) determine the ability of goats to produce high quality milk efficiently in the various goat-producing regions of the United States; (2) to locate individuals, families, strains, breeds, and types of goats most efficient in milk production under various environments; (3) to determine the genetic principles that form the basis for improving production and (4) to introduce the application of these principles into the goat-breeding industry. Current work includes studies on effects of line breeding on milk production, use of hormones to induce lactation, and determination of maximum milk production as affected by ages of does.

B. Currently Active Line Projects

b-2-4-2 - Selective mating and line breeding of Toggenburg goats to increase milk and butterfat production. To determine the inherent capacity of certain Toggenburg goats to produce nutritious milk, and to select and line-breed the best producers to establish better strains.

b-2-4-4 - Use of hormones to induce lactation in milk goats. To identify female goats at the earliest possible age -- even before their first breeding season -- that have superior capacity for milk production.

C. History and Evolution of this Work

At the turn of the century, a few of the more progressive American goat breeders were beginning to realize that the industry needed improvement in milk production of goats and an increase in commercial-size flocks, relatively few of which existed at that time. Introduction into the United States of some European strains presented possibilities for cross breeding with native stok to develop better milkers. When the Bureau of Animal Industry, in 1909, undertook to aid breeders in increasing goat-milk production through selective breeding, it selected Toggenburg and Saanen breeds and conducted its experiments with them until 1943. Since that year, all goats under study have been of the Toggenburg breed, This breed comprises the largest number of improved milk goats in the United States. About a decade ago, special efforts were directed by Bureau goat specialists to increasing butterfat content without lowering the milk production. This work is being actively continued, and carefull consideration is given to the properties that make goat's milk useful for infants and invalids who cannot use cow's milk.

D. Funds -- Annual Expenditures

With goat breeding investigations financed from funds covering work on several lines of research with sheep and goats, estimates in early years are difficult to obtain. Direct expenditures for all sheep and goat husbandry investigations varied from about $80,000 in 1923 to about $84,700 in 1934 and averaged slightly over $88,000 annually. During this period there were expenditures for three projects (maintenance of station at Beltsville and fundamental research on animal genetics and nutrition) for which no basis for distribution is available now. The average expenditure for these three projects from 1923 to 1934 was about

$92,000 annually. The direct costs for goat breeding investigations varied from about $6,000 in 1935 to about $9,000 in 1943. Expenditures ranged from about $8,000 in 1944 to $12,000 in 1950.

E. Examples of Outstanding Accomplishments

Definite improvement in quantity of milk produced per year and length of lactation period. In the grading-up work, in each generation the best producing does were retained for top-crossing in succeeding generations. In the generation representing the fifth top-cross of purebred sires, the lactation period had been increased 145 percent and the annual milk yield 335 percent over those of the native American does. Animals such as these greatly increase the profits of goat owners.

Demonstration that progeny testing is a practical and effective means of selecting sires for their ability to transmit high milk-production to their daughters. Use of sire breeding records and tests of their progeny enables goat breeders to raise more productive milk does and thereby to increase milk sales.

Discovery that hermaphrodism (dual sex) in sheep can be controlled by the use of one horned parent in matings. During the last 5 years such matings have resulted in the absence of hermaphrodite kids. It has been found that hermaphrodism is transmitted as a recessive character associated with the polled, or hornless, condition.

Determination of ages when milking does reach their maximum milk production. A comparison of the records of does of different ages in the Department's herd at Beltsville showed that the best ages for both milk production and length of lactation were between 4 and 6 years, but that the change in length of lactation was not so great as that in milk production. These facts serve as a guide to the goat breeder in maintaining his herd at the most profitable status as far as the ages of the animals are concerned.

Indication of the present impracticability of using hormones for stimulation of extra-seasonal breeding in goats. Although this finding is negative, it enables milk-goat producers to avoid striving for a spread of the breeding season by the use of hormones that have already been found ineffective.

Discovery that age of dam in milk goats influences number of young. The tendency is for older dams to produce more kids. It was found that 2-year-old dams produce an average of 1.7 kids; while at 7 years of age, the average is 2.1 kids. This finding serves as another guide to the breeder as to how long to keep does in the flock.

F. Some Additional Work Needed

Use of hormones to stimulate estrus (heat Period) and lactation in goats. Results thus far have been varying and inconclusive, but there seems to be promise of useful results when more is known about the effects of hormones on reproduction in goats and other animals. An understanding of the response to be expected when hormones are applied to normal breeding animals is essential.

Determination of the practicability of predicting a doe's future inherent level of milk production before her first breeding. If such a procedure can be evolved, it would permit early culling of poor milk producers by the breeder and reduce milk losses that now can be done only after the young doe is bred. It would also be of great help in a breeding program, for the strains producing the inherent poor milkers could thus be determined.

Value of crossbreeding for milk and butterfat production in goats. Crossbreeding has been used to advantage in dairy cattle and other classes of livestock. Hybridization -- using two and three breed crosses -- in other animals has resulted in increased persistence and volume of production. Investigation of the possible advantages of goats, therefore, seems decidedly worth while.

BREEDING OF FUR ANIMALS, INCLUDING DOMESTIC RABBITS
(BAI - No. b-8-1 - Federal - State - Regular Funds)

A. Purpose and Nature of Current Work

To (1) develop practical methods of breeding (including artificial insemination) of recently domesticated foxes, minks, martens, and other farm-raised fur animals to increase litter size and the quality, density, and color of fur; (2) improve the ability of domestic rabbits to produce meat, fur, and wool; (3) develop superior strains of fur animals. Current emphasis is being placed on time and frequency of breeding, breeding for color changes, and selective mating to develop superior strains.

B. Currently Active Line Projects

b-8-1-1 - To develop a strain of domestic rabbits that is superior for meat and fur production.

b-8-1-2 - Angora rabbit wool production. To study the inherited ability of the animals to produce wool and to improve the quantity and quality of wool produced by selective breeding.

b-8-1-4 - Fur improvement in minks and foxes. To determine the inheritance of various mutations, or changes, in color and physical characteristics in order to develop breeding practices for eliminating undesirable traits and retaining and improving the desirable ones; to study all factors affecting quality of pelts.

b-8-1-5 - Superior strain of blue foxes. To develop a silvery strain of blue foxes by crossing blue and white foxes and making selective matings.

C. History and Evolution of This Work

Fur farming with wild animals was in its infancy when the United States Department of Agriculture began its first project in 1912. These new farmers encountered difficulties almost immediately in raising minks, martens, foxes, and other fur animals in captivity. They sought help and, in 1916, to aid the young industry a research station was established at Keesville, N. Y., after exploratory investigations had been conducted for several years by the Bureau of Biological Survey. In 1921, this station was moved to the present location, Saratoga Springs, N. Y., where research on silver foxes, minks, martens, and rabbits was conducted. Pair mating of foxes was the common practice until about 1930, when methods for successful polygamous mating were developed through management and selective breeding. Later, research on fur-animal breeding was expanded by cooperative work with the Carnegie Institute of Washington at Johns Hopkins, Baltimore, Md., and still later by similar work at Swarthmore College, Swarthmore, Pa., under a grant from the Special Research Fund of the Department. Rabbit-breeding research was begun in 1927 when the United States Rabbit Experiment Station was established at Fontana, Calif., in cooperation with the rabbit breeders of that area and a private company. Emphasis was placed on selective matings to produce a superior strain of rabbits for meat and fur, and on determining the proper age for breeding, when to breed after kindling (birth of litters) to obtain a large litter of healthy young that will grow well, and the effect of climate on breeding activities. Research on the breeding of blue foxes, martens, and minks was begun in 1937 at Petersburg, Alaska. The initial work involved the crossing of white and blue foxes to develop a more silvery blue fox and to fix these desirable characteristics. Attempts are also being made to develop a system of management to get martens to breed in captivity. In 1939 all activities of the Bureau of Biological Survey including fur-animal investigations were transferred to the Department of the Interior, but in 1946 they were returned to the Department of Agriculture. Research on minks and foxes was expanded in 1947 through cooperation with a North Central State where much of this country's fur farming is concentrated. Special attention is being given to the inheritance of the various color mutations in minks and foxes, fur quality, and other inherited factors of economical importance.

D. Funds--Annual Expenditures

Expenditures for this project since its transfer to the Bureau of Animal Industry have been as follows:

Fiscal Year 1947	$18,000
Fiscal Year 1948	20,000
Fiscal Year 1949	20,000
Fiscal Year 1950	24,000

E. Examples of Outstanding Accomplishments

Adoption by the entire mink industry of the practice of breeding minks later in the season (about March 10) with much more satisfactory results than with earlier breeding. This practice grew from research findings by the Bureau.

Definite knowledge of the inheritance of numerous color mutations in minks and foxes, providing a basis for breeders to obtain the maximum number of animals of the most valuable types.

Determination of the best time in the heat period to breed silver foxes. It was found that late in the second day of the heat period was the best time for highest percentage of pregnancies and the largest litters. Breeders are getting consistently better results from this procedure.

Development and perfecting of a technique for restraining does for mating and hand determination of pregnancy 14 days after breeding. Rabbits normally ovulate when bred and thus can be bred at any time. By detecting unbred does and rebreeding immediately, the maximum number of pounds of young rabbits can be produced annually.

Determination that 73 percent of rabbit does, bred immediately after a false pregnancy period lasting up to 18 days, will become pregnant. This knowledge permits breeders to obtain a higher percentage of production from such animals.

F. Some Additional Work Needed

Studies are needed on inheritance of quality of fur, desirable and harmful physical characteristics and such other factors as are instrumental in developing superior furs.

Testing the breeding ability of young female rabbits on various levels of feeding in order that production may begin as early as possible and be carried on most economically.

Practicability of colony methods of raising rabbits to reduce labor and cost of equipment, and to determine the value of grazing.

Production of strains of rabbits superior in meat, fur, and wool and of superior strains of minks and foxes that will bring greater returns to breeders than those in use at present.

Methods of obtaining better reproduction in martens. Only about 15 percent of penned martens produce young. Intensive study should be made of management methods and of diets that will result in satisfactory reproduction of these scarce animals in captivity.

SHEEP BREEDING AND IMPROVEMENT IN THE SOUTHWEST
(BAI - SRF-2-2 - Federal-State-Special Funds)

A. Purpose and Nature of Current Work

To develop breeds and strains of sheep suitable to the physical and economic requirements of the southwestern ranges. Current work is aimed particularly toward the production of wools having properties highly satisfactory to producers, manufacturers, and other users of these wools. Although wool is the primary concern of these investigations, an effort is being made also to develop, in the respective breeds and strains of sheep, as good mutton conformation as possible while producing wools having the desired properties. In addition, work is under way to provide more efficient methods of selecting breeding animals and of making more rapid progress in breeding and improvement of sheep for southwestern ranges.

B. Currently Active Line Projects

SRF-2-2-2 - Improvement of Navajo sheep by line-breeding and selection in the Navajo strain. To improve the well-adapted but low-producing old-type Navajo sheep in quantity and quality of wool and lambs produced, and to fix desirable genetic characters that will increase the usefulness of these sheep in the development of better breeds for southwestern ranges.

SRF-2-2-5 - Improvement of Navajo sheep by cross-breeding and selection for the production of wool suitable for both hand and commercial methods of manufacture. To develop improved Navajo crossbred strains of sheep, adapted to southwestern ranges, that will produce wool having properties suitable to Indian handicraftsmen and commercial users of coarse wools, and increase net returns to sheepmen from the production of wool and lambs.

SRF-2-2-6 - Improvement of Navajo sheep by cross-breeding and selection for range production of wool and lambs. To develop improved Navajo crossbred strains of sheep, adapted to southwestern ranges, that will increase net returns to sheepmen from the production of apparel wools and feeder lambs.

SRF-2-2-7 - Development of an efficient method of selecting breeding animals used in the program of the Southwestern Range and Sheep Breeding Laboratory, Ft. Wingate, N. Mex. To develop selection indexes that will have the greatest value for measuring the genetic merit of sheep used in the experimental breeding program of the Southwestern Range and Sheep Breeding Laboratory.

SRF-2-2-8 - Studies of the adaptability, to southwestern ranges, of crossbred strains of sheep having different proportions of Navajo and improved blood. To determine the percentage of inheritance from old-type Navajo sheep that is necessary, in improved Navajo crossbred strains, to maintain adequate adaptability to southwestern ranges, and to secure maximum lifetime production of wool and lambs.

C. History and Evolution of This Work

Development of breeds and strains of sheep adapted to southwestern ranges and to the economic requirements of the sheepmen was begun in 1935 in cooperation with the Bureau of Indian Affairs, Department of the Interior, and the Soil Conservation Service of the Department of Agriculture. The low productivity of sheep owned by the Navajo Indians and the marked decline in quality of Navajo hand-woven blankets and rugs focused attention on the need for research in sheep breeding and wool technology applicable in improving the Navajo sheep industry, which represented the main source of livelihood of 60,000 Indians. The foundation flock of sheep purchased for the experimental breeding work consisted of about 800 old-type Navajo ewes and 20 rams. Improvement of the Navajo sheep was directed along two lines, as follows: Selective matings within the Navajo strain and cross-breeding of old-type Navajo ewes with selected purebred rams of certain coarse-wooled breeds. Obtaining of basic information on the physical properties of wools suitable for Navajo hand methods of processing permitted accurate definition of the objective of the breeding work with respect to wool. Furthermore, improvements in laboratory techniques for evaluating fleece and fiber characteristics of Navajo sheep made possible more accurate selection of desirable breeding animals. Development of breeds of sheep adapted to southwestern ranges was expanded in 1949 to include work on development of a type of sheep that will produce better apparel wool.

D. Funds--Annual Expenditures

Expenditures covering this work averaged about $9,800 from 1938 to 1948. Expenditures were $13,200 for 1949 and $15,300 for 1950.

E. Examples of Outstanding Accomplishments

Improvement in productiveness and quality of old-type Navajo sheep. By means of selective matings of old-type Navajo ewes and rams maintained in the experimental flock, average fleece weight of breeding ewes has been increased about 50 percent with a gain of 15 percent in average body weight. The incidence of objectionable fibers in the fleeces of the Navajo sheep also has been sharply reduced, resulting in a marked improvement in quality of the wool for hand weaving. Desirable segregates with nonhairy or slightly hairy fleeces are now being obtained with greater frequency. Thus definite progress is being made in the development of an improved pure strain of Navajo sheep.

Improvement of Navajo sheep by crossbreeding. Various crosses have been developed and are being integrated to produce new strains having inheritance of 3/8 from the Navajo sheep and 5/8 from the improved coarse-wooled breeds. By cross-breeding and selective matings of the progeny, average fleece weights of ewes and rams have been increased about 100 percent and improvement in quality of the wool produced has greatly increased its market value as well as its usefulness for Navajo hand weaving. An increase of about 30 percent in body size of mature animals and considerable improvement in mutton conformation of the Navajo crossbred sheep have been accomplished without appreciable loss of adaptability, fertility, and liveability compared with full-blood Navajo sheep maintained in the same environment.

Accuracy of selection improved. Environmental influences often tend to obscure the true genetic merit of animals and thus complicate the problem of selection by sheepmen of those animals that have greatest breeding value. Accuracy of selection among weanling lambs, is now aided by adjusting staple length of wool, body weight, and scores for body type and condition (degree of fatness) of lambs at weaning age for effects of climatic, forage, and other known factors of environment.

F. Some Additional Work Needed

Fixation of desirable characteristics in Navajo crossbred strains of sheep by line-breeding. Each of the improved Navajo crossbred strains of sheep that are now being developed must be line-bred for about eight sheep generations (a sheep generation is about 3½ years) to genetically fix desirable fleece and body characteristics of the sheep. At the same time intensive selection of the progeny should be made. To improve still further accuracy of selection and increase the rate of progress, selection indexes for yearling ewes and rams and mature breeding rams will be needed.

Determination of the nutritive value of edible range plants at different seasons of the year. The productivity of range sheep may be considerably reduced by deficiencies of the natural forage. In some areas of the Southwest, range grasses and other forage plants are known to be deficient in phosphorus and calcium. More information on the nutritive value of the various range plants consumed by sheep at different seasons of the year is needed in order to indicate the supplemental feeds that are necessary for a properly balanced diet and full production of wool and lambs. Chemical analyses of representative samples of range forage collected at different seasons of the year would provide the information needed.

SHEEP BREEDING AND IMPROVEMENT FOR WESTERN RANGES
(BAI - SRF 3-6 - Federal-State - Special Funds)

A. Purpose and Nature of Current Work

The main objective is to improve sheep for more efficient lamb and wool production on the range. The current work is concerned with improving the Rambouillet breed by selecting for sheep whose faces are as free as possible of wool, since a wool-covered face makes the animals wool-blind; to select for wrinkle-free bodies, longer wool staple, more uniform wool throughout the fleece, and improved fleshing qualities. Studies are also being conducted on line breeding, and the testing of lines for their combining ability with other lines, and the development of simple selection and breeding programs that will be practical for the commercial producer of rams for the range trade.

B. Currently Active Line Projects

SRF-3-6-(1) Systems of breeding for locating strains of Rambouillet sheep possessing inherited qualities that will improve strains with which they are crossed. To develop inbred lines with emphasis on selection for usefulness. The useful qualities emphasized are meat-producing form, length of staple, faces free from wool, heavy clean fleeces of uniform quality, and high lamb production. Inbred lines are then tested for combining ability in line crosses and top crosses.

SRF-3-6-(2) Inheritance of various undesirable characteristics of Rambouillet sheep. To determine how various undesirable characteristics such as wool blindness, skin wrinkles, and hair in the fleece are inherited so that methods can be developed for eliminating those weaknesses from the breeding stock.

SRF-3-6-(3) Reproduction of Rambouillet sheep. To determine the relation of quality of semen to fertility, sexual maturity of ram lambs, and factors affecting fertility of ewes.

SRF-3-6-(4) Wool production of Rambouillet sheep. To study fiber uniformity within and between various regions of the fleece. Studies are also being made of uniformity of wool fibers and spinning qualities of various grade selections (sorts) of Rambouillet fleeces.

SRF-3-6-(7) Methods of improving lamb production in range sheep. To develop more efficient methods of selecting for high lamb production by determining the effects of environment, heritability, relationship to other important traits and the subsequent incorporation of lamb production in selection standards.

C. History and Evolution of This Work

Requests by western sheepmen for research to aid in improving range sheep for more lamb and wool production led to the allotment of special research funds in 1937 for this project. Work was begun in the Western Sheep Breeding Laboratory in the fall of 1937 at the U. S. Sheep Experiment Station, Dubois, Idaho, where Rambouillet sheep, grazing lands and many other facilities were already available for operating the research program. Roughly, 1,200 breeding ewes have been involved in the project each year since its inception. Each of the agricultural experiment stations of the 12 Western States which, with the Bureau of Animal Industry, constitute the coordinating body of the Western Sheep Breeding Laboratory, agreed that the need for improving Rambouillet sheep--the basic breed of the western ranges--was a priority matter. Experiments have been essentially concerned with breeding off the excessive wool on the faces of the sheep which rendered them wool-blind, and breeding off the neck and body skin wrinkles, which were definite causes of skin injury during shearing and made the wounds vulnerable to flies and other insects. These wrinkles were a source of reduction in the selling price of the lambs, and the cause of disturbing variability in fleece quality. Research has also been directed toward producing a longer staple wool, thereby increasing the yield of clean scoured wool per sheep as well as the price, since the long-fiber wool sells at a higher price per pound than shorter wools. Such wools would be of particular benefit to growers who shear twice a year. Increased staple length would also reduce the shrink in wool.

D. Funds--Annual Expenditures

Annual expenditures from the Special Research Fund have ranged from slightly over $69,000 in the fiscal year 1937 when the project was established to about $70,000 in the fiscal year 1949. Average annual expenditures over this period have been about $60,000. Expenditures in the fiscal year 1950 were $76,500.

E. Examples of Outstanding Accomplishments

Development of more "open-face" sheep. The Rambouillet ewes with open faces in the Department's flock at Dubois, Idaho, average 11 1/2 pounds more lamb per year than the wool-blind ewes at no extra cost on the range. This improvement has broad application as there are at least 8 million wool-blind ewes on the western ranges. The American Rambouillet Sheep Breeders Association now describes the ideal Rambouillet sheep as one with an "eye area free from wool to insure good vision at all times," and the breeders are striving to conform to that ideal.

Breeding of smoother bodied, wrinkle-free Rambouillet sheep. About 90 percent of the Department's Rambouillet flock is now free from skin wrinkles. The significant contribution lies in the elimination of price dockage for "heavy pelt" lambs. Roughly, two to four million or more lambs are subject to dockage each year, which varies from 1/2 to 2 cents per pound. Breeders of fine-wool sheep now recognize the disadvantage of wrinkled bodies and pay premiums for rams that are free from wrinkles.

Increased length of staple in Rambouillet wool. Length of staple of wool from the progeny of rams bred for long staple in the Rambouillet flock, has been found to be as much as 15 percent greater than the staple length of the progeny of the stud rams in use in other Rambouillet flocks. Sheep producers purchase these long-staple surplus rams for use in their own flocks.

Developing Rambouillet rams without horns. The "new" Rambouillet ram is also being developed, by the Department, without horns. The incidence of infection by flies and bodily injury is much less in polled, or hornless, rams than in horned rams. Moreover, horned rams cause more damage to fences and equipment and require more room for transportation or in sheds. Breeders now pay a considerable premium for rams without horns.

Wool shrinkage determinations. Core-testing of wool for shrinkage has been found to be vastly superior to visual appraisal. For several years, the entire clip of the Western Sheep Breeding Laboratory was core-tested for shrinkage and results compared with final, actual shrinkage. The method, tried out on some 20,000 pounds of wool, proved far superior to the old system of "estimated" clean wool content. The outstanding accomplishment of this effort is the release from selling, by the "stone age" method of barter, the most expensive commodity that is produced on our rams and ranges. Wool now sells for over $1.75 per pound on the cleaned scoured basis. Millions of pounds of wool are now sold annually subject to the core test values, which is directly bringing prices closer to actual value.

Discovery of effective means of increasing lamb production. Studies on lifetime lamb production of more than 1,000 ewes on the range have shown that those having twins produce an average of about 40 pounds more lamb per year than ewes having singles and are, therefore, definitely more profitable. Twin production was found to be heritable and ways of selecting more effectively for twinning have been developed. This study has also shown the culling ewes on the basis of their first year's lamb production is effective in increasing the productivity of the flock immediately.

Increasing effectiveness of selection. Methods have been developed to increase the effectiveness of selection of breeding stock for improving range sheep. These involve allowances for effects of environment, heritable traits, and similar factors, to permit accurate judgment of their breeding qualities.

F. Some Additional Work Needed

Establishment of strains that will breed true for complete freedom from wool covering on the face of sheep. Such an accomplishment would make it possible for American sheepmen to profit by several million dollars each year through greater efficiency of lamb production on western ranges.

Fixing of the polled or hornless characteristics in range Rambouillet rams to effect more economical production of sheep on western ranges. Although needed for defense against enemies in the animals' wild state, horns on sheep today are decidedly more of a detriment than an advantage. It has been found that injuries and deaths due to crowding and fighting are much less among polled sheep and losses to the sheep grower are accordingly smaller.

Determination of the combining ability of selected lines of inbred Rambouillet sheep and of certain of these lines with sheep of other breeds, as a means of further improvement in lamb and wool production, needs urgent attention. Exploratory tests in this field of crossing linebred sheep indicate that certain lines will combine very successfully for increased rate of growth in the wool and meat of the resulting offspring. Considerable work is needed, however, to locate and identify the lines most efficient in their combining ability.

SHEEP FEEDING

(BAI - No. b-2-2 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

To (1) determine the nutritive requirements of sheep and the value, for these animals, of important feeds and forages adapted to the various regions of the United States; (2) the value of various diets and rations for producing growth, maintenance, and reproduction of individual sheep, breeds, types, and classes of sheep and lambs; (3) the influence of various feeds and forages on the growth of sheep and the quality of mutton, lamb, wool, and fur. In the current work, research is being conducted on the control of urinary calculi, the requirements for cobalt and other mineral elements, and related nutritional problems.

B. Currently Active Line Projects

b-2-2-6 - Relation of sorghum crops in the ration to formation of calculi, or stones, in sheep. To determine the reason why the use of sorghum feeds causes urinary calculi formation in sheep and the means of preventing this disorder.

b-2-2-7 - The role of cobalt and other inorganic elements in sheep nutrition. To study the needs for cobalt and other inorganic elements in rations of sheep and the methods of correcting the condition caused by an insufficiency of these elements.

C. History and Evolution of This Work

The westward movement of the sheep industry in this country early in 1900 brought a realization to sheepmen that research was needed to find improved ways for the profitable feeding of sheep. In the West, problems of grazing in areas of low rainfall and other unusual conditions called for solution. In the East, sheepmen sought to retain a portion of the industry through improved feeding practices. To meet these needs, the Bureau in 1906 began research on feeds and forages for sheep and within a few years this study had been extended to various locations of the United States in an effort to find the grazing and feeding methods best adapted to specific regions. At Dubois, Idaho, feeding problems of the western ranges have been under research since 1920. At Middlebury, Vt., the activities of the project have dealt with sheep feeding in the North Atlantic area. At Newell, S. Dak., the work was devoted largely to fattening of lambs on feeds common to that area. This phase of the project was begun in 1923 and continued until 1943. Sheep-feeding problems of broad and fundamental importance are studied at Beltsville, Md.

D. Funds -- Annual Expenditures

With sheep feeding investigations financed from funds covering work on several lines of research on sheep and goats, estimates for early years are difficult to obtain. Direct expenditures for all sheep and goat husbandry investigations varied from about $80,000 in 1923 to about $84,700 in 1934, and averaged slightly over $88,000 annually. During this period there were expenditures for three projects (maintenance of station at Beltsville and fundamental research on animal genetics and nutrition) for which no basis of distribution is available now. The average expenditures for these three projects from 1923 to 1934 was about $92,000 annually. The direct costs for research on sheep feeding varied from about $15,000 in 1935 to $17,000 in 1943. Expenditures for this work have ranged from about $17,000 in 1944 to $25,200 in 1950.

E. Examples of Outstanding Accomplishments

Discovery that lambs fed and held under similar conditions vary widely in gains and efficiency in use of feed. Differences of as much as 38 percent were found between the lowest gaining and the most rapidly gaining lambs, and differences of 36 percent between the least efficient and most efficient in the use of their feeds. Such variation emphasizes the importance of careful selection of feeder lambs from strains of sheep that will gain weight rapidly and profitably and that will be highly efficient and profitable in the utilization of their feed for the production of lamb meat.

Determination that feed for sheep is far more important than the temperature of their environment in terms of gain in body weight and weight of wool. It has been found that Columbia sheep in a hot climate and Columbia sheep of the same strain and rearing in a cool climate, all well-fed, gained about the same in body weight and produced about the same weight of wool. This result indicates that when good feed is provided for sheep, marked differences in the temperature of their environment are of small importance in wool production.

Development of a lamb-fattening diet producing the cheapest gains in weight in western South Dakota consisted of barley, pressed sugar beet pulp, molasses, beet tops, and alfalfa hay. Adding the pressed sugar beet pulp to corn and alfalfa hay or barley and alfalfa hay increased the efficiency of these diets. In this important sugar-beet producing area where sheep production is also important, this finding has been applied with substantial profits to the lamb-feeding industry.

Finding that feeding soybeans with grain to fattening lambs yields good results. Higher percentages of the protein and fat were digested by fattening lambs when alfalfa hay and soybeans were fed than when alfalfa hay, corn, and cottonseed meal were fed. No appreciable softening of the body fat occurred in fattening lambs fed soybeans. This finding is in contrast to the usual softening of pork that results from feeding soybeans to pigs and provides a potential feed outlet for oil whenever economic conditions require such adjustment.

Discovery that feeding range oats in addition to alfalfa hay increases the growth of ewe lambs and improves their development as breeding ewes in the intermountain range area. This result was obtained with four breeds -- the Columbias, Rambouillets, Targhees, and Corriedales.

Discovery that fresh grasses have a high vitamin E content, which is essential for good nutrition. Results from this project indicate that a sheep consuming 14 pounds of bluegrass per day will obtain about a gram of alpha-tocopherol (the essential element in the prevention of stiff lamb or white muscle disease), or as much as is found in ½ to 1 pound of wheat germ oil, which costs several dollars per pound. Substantial savings in the feeding of sheep can be effected through fresh grass pastures.

Finding that supplemental feeding of cottonseed cake or oats to sheep on winter range or in winter feed lots increased the phosphorus content of the blood of breeding ewes. These results have helped range sheepmen increase their lamb and wool production through the feeding of one of these supplements during the winter, when low blood phosphorus levels occur in breeding ewes accompanied by losses at lambing time and diminished growth of lambs.

Determination that flushing, or extra feeding of ewes at breeding time, increases lamb yields through twinning. This increase has been found to average 187 lambs per 1,000 ewes. Sheep producers find this flushing practice very profitable where feed conditions are favorable for lamb production.

Finding that the feeding levels for Karakul breeding ewes had no significant effect on the fur of their newborn lambs with respect to size of pelt, size of curl, tightness of curl, luster, and thickness of skin. These results do much to dispel a deep-seated idea that restricted nutrition favors growth of more desirable curl and better pelts. Greater dependence, therefore, can be placed on breeding in the production of superior lamb-skin fur.

F. Some Additional Work Needed

Improvement of the sheep forages of the western ranges are especially needed to cut cost of production through increased grazing capacity.

PRODUCTION AND PROPERTIES OF GOAT'S MILK
(BAI No. b-2-5 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

To determine the important nutritive properties of goat's milk, and the influences of breeding, feeding and other management practices on such properties as well as on the production of milk. Current emphasis is being given to selection of strains of goats that produce large amounts of milk having the nutrients of greatest benefit to persons who require goat's milk in their diet.

B. Currently Active Line Projects

b-2-5-5 - The effect of different protein and fat supplements in concentrate mixtures on milk and butterfat production of milking goats. To determine the possible effects of certain different protein and fat supplements on the quality and quantity of the milk produced by goats.

C. History and Evolution of This Work

During the first 20 years of this work, from 1909 to 1929, major attention was given to production and management phases of dairy goat husbandry. Because of the constant demand for information on goat's milk, presumably because it is easy to digest, an intensive study lasting nearly 10 years was begun in 1929 on the nutritive properties of goat's milk. Comparison studies with cow's milk were carried out during this period with special reference to the properties of goat's milk providing the nutritive requirements of infants, and of adults suffering from digestive disorders. These studies were aimed primarily at vitamin and special nutrient content as well as the effects of pasteurization on the use of goat's milk. After establishing these special nutrient facts, work in recent years has been directed toward seeking out milk goats which produce not only more milk, but those also producing milk with high nutritive qualities.

D. Funds -- Annual Expenditures

With goat's milk studies financed from funds covering work on several lines of research with sheep and goats, estimates for early years are difficult to obtain. Direct expenditures for all sheep and goat husbandry investigations varied from $80,279 in 1923 to $84,692 in 1934, and averaged slightly over $88,000 annually. During this period there were expenditures for three projects (maintenance of station at Beltsville and fundamental research on animal genetics and nutrition) for which no basis for distribution is available now. The average expenditure for these three projects from 1923 to 1934 was about $92,000 annually. The direct costs for goat's milk studies varied from $11,900 in 1935 to $9,700 in 1943. Expenditures for this work ranged from $9,500 in 1944 to $11,900 for the fiscal year 1950.

E. Examples of Outstanding Accomplishments

These studies established that goat's milk has a soft curd, small fat globules, and a rather high buffer index or resistance to acidity. These properties explain the reason why goat's milk is easily digested and why it is often prescribed for both infants and adults who are unable to consume cow's milk. Goat's milk has a high ratio of albumin and globulin to casein, and a greater quantity of the fatty acids than cow's milk. Studies reveal that it is similar to that from cow's in vitamin A and D, and relatively high in thiamine. Spring and summer milk has more vitamin C than fall and winter milk. Exposure of the milk to air and light materially reduces the ascorbic acid content.

Pasteurization of goat's milk increases the solubility of calcium and phosphorus and reduces the curd tension. This process has improved the keeping quality more than the flavor of fresh goat's milk. Pasteurization by holding the milk at not less than 142° F. for 30 minutes caused a decrease of from 35 to 45 percent in the content of ascorbic acid. Pasteurization improves its safety, without adverse alteration, as in cow's milk.

Feeding a concentrate mixture of 13 percent protein is adequate for milk production but a 10-percent protein level is insufficient for highest yield of milk. Results of tests indicate that a concentrate mixture of feed containing 13 percent protein is adequate for best milk production provided it is fed with a good quality legume roughage. Goat raisers need to know the amount of protein concentrate to buy in supplementing home-grown feeds.

F. Some Additional Work Needed

Development of goats that will produce more milk, and milk of higher fat content. Yields should be at least 1,200 pounds of milk per doe per year, with butterfat content approximating 4 percent. At present goat-milk production in the United States is probably less than 900 pounds a doe per year, which is unprofitable. Goat's milk is relatively low in butterfat in such breeds as Toggenburg and Saanen. Research for the solution of problems in producing adequate quantities of milk should be in the fields of breeding, feeding, and management. Influencing butterfat content of the milk appears to be largely in the field of improved breeding through selective mating and line breeding.

Measurements and methods of identifying the milks of individuals and strains of does with respect to merit in flavor and nutritive properties, other than butterfat content, which contribute to the special usefulness of goat's milk. If the does having special merit along these lines could be identified, such finding would provide a basis for improving goat's milk through the application of goat breeding methods.

FUR-ANIMAL FEEDING AND NUTRITION
(BAI - No. b-8-3 - Federal-State - Regular Funds)

A. Purpose and Nature of Work

To determine nutritive requirements of various species of pen-raised fur animals, including domestic rabbits, for meat, fur, and wool and the most economical sources of feeds to meet their requirements and produce the best fur. In current work, emphasis is given to determining the protein, fat, mineral, and vitamin requirements in the diet for rearing healthy stock. Another important objective is the finding of satisfactory substitutes for expensive raw meat in the diet.

B. Currently Active Line Projects

b-8-3-1 - Protein requirements of fur animals. To determine the protein requirements of minks and foxes during breeding, pregnancy, suckling, growth, maintenance, and fur growing in order to keep this expensive part of the diet to a minimum, and thereby permit more economical production.

b-8-3-2 - Fat requirement of fur animals. To determine what levels and kinds of fat are most desirable for growth, feeding efficiency, and development of good fur.

b-8-3-3 - New sources of feed for fur animals. To find new and economically satisfactory feeds as a substitute for horse meat and to determine the relative value of cereal products for minks, foxes, and martens. Emphasis has been given to the use of chicken waste, packing-house byproducts, potatoes, and cereals.

b-8-3-4 - Feeding and management of pregnant does to keep them in top condition for highest production. To determine the effect of full feeding and restricted feeding after the fourteenth day of pregnancy.

b-8-3-6 - Sea fish, sea mammals, and their products as fur-animal feeds. To determine the quantities of Alaskan fish-cannery wastes, principally salmon and halibut, and the proper supplements to feed fur animals.

C. History and Evolution of This Work

Economic feeding of wild fur animals in captivity was one of the earliest problems that faced farmers who entered this new and relatively hazardous field. To meet this pressing need, poineer work was undertaken in 1916 by the Bureau of Biological Survey, of the Department, following some preliminary collaboration with private fur farmers. Full-scale research did not get under way until in the 1930's. The first experiments were by trial and error to find proper mixtures of horse meat and other ingredients for satisfactory diets. Many of the packing-house byproducts were tested for suitability; then the substitution of beef meal, tankage, and fishmeal for the raw meats. Consideration was also given to the use of vegetable proteins and scrap fish and fish-cannery waste. In 1938 fundamental nutrition research with foxes and minks was begun in cooperation with Cornell University, emphasis being given to vitamin, protein, and fat requirements in the diet. These investigations are still in progress. The development of the rabbit industry in the West with the resulting need, on the part of the producers, for economical and growth-promoting feeds led to the establishment, in 1927, of the United States Rabbit Experiment Station at Fontana, Calif., in cooperation with rabbit breeders and a private company. Attention was given both to suitable feed mixtures and to effective methods of feeding. A study was also made of a large variety of feeds in relation to the troublesome bloat in these animals. The expansion of the fish cannery industry in Alaska resulted, in 1937, in research work at Petersburg to test the value of whole scrap fish, fish-cannery waste both frozen and cooked, and other readily available feeds for fur animals. In 1939 the functions of the Bureau of Biological Survey, including work on fur animals raised in captivity, were transferred from the Department of Agriculture to the Department of the Interior, but in 1946 were returned to Agriculture.

D. Funds--Annual Expenditures

Expenditures for research on feeding and nutrition of fur animals since the transfer of the activity to the Bureau of Animal Industry have been as follows:

Fiscal year 1947 - $26,500
Fiscal year 1948 - 28,900
Fiscal year 1949 - 35,000
Fiscal year 1950 - 42,000

E. Examples of Outstanding Accomplishments

Determination of the digestibility of various types of feeds by minks and foxes, enabling fur farmers to make a better selection of economical feeds.

Determining the value, as feed for fur animals, of numerous byproducts from packing houses and fish canneries and other waste products. Information obtained on their relative efficiency and proper quantities to be fed has resulted in a considerable saving to fur farmers through the use of these comparatively cheap feeds.

Finding the vitamin A and the thiamine and nicotinic acid (two members of the vitamin B family) requirements of fur animals for health, reproduction, and good fur. As a result, fur farmers can balance diets and thereby prevent losses due to vitamin deficiency disorders.

Determining the amount of protein and fat needed by minks and foxes at several stages of development and maintenance. This information is being used by producers in providing adequate diets for their animals.

Development of a selective self-feeder system and diet of whole grains and protein supplement in addition to legume hay for domestic rabbits, resulted in increased daily gains and more economical commercial production. Small rabbit growers have found this method especially helpful in solving ration and feeding problems.

F. Some Additional Work Needed

Digestion trials with minks, foxes, and martens, of promising new feeds to formulate better and more economical diets for these animals so recently removed from the wild. Such trials have yielded exceedingly worth-while results with other livestock.

Special digestion trials with rabbits are necessary because of their normal practice of eating dung, somewhat similar to rumination in cattle. This peculiarity of rabbits makes undependable the application of digestion trials used with other types of livestock.

Nutrient requirements for domestic rabbits. Though some of the nutrient requirements of rabbits for certain periods of their lives are known, additional studies of many nutrients essential to growth, reproduction, and lactation are needed.

Meatless diet for minks. Foxes can be reared on diets without any fresh meat. If such diets can be found for minks, much of the labor and equipment necessary for preparing and holding raw meats can be eliminated and a more economical diet can be used.

New sources of cheap and satisfactory substitutes for horse meat and other expensive feeds. Many fur farmers have discontinued operations because they could not make a profit owing to a lack of a reliable substitute for horse meat.

SHEEP MANAGEMENT
(BAI - No. b-2-3 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

To determine the most efficient practices for growing sheep, the influence of specific factors on the thrift of sheep and lambs, and on the production and quality of mutton, lamb, wool and fur. Current work covers studies of a wide range of management problems. These include research on systems of pasturing the ranges of the West for the most efficient use and economical production of meat and wool, as well as investigations of types of forage and methods of pasturing forage crops in the farm States. Methods of caring for sheep in the winter, type of feed best suited to the needs of ewes at lambing, saving young lambs, and for shearing, tying, grading, sorting and packing of wool for highest returns are also under study.

B. Currently Active Line Projects

b-2-3-1 - Studies in sheep grazing on spring-fall range in the intermoutain region. To determine how sheep and the range are affected by climate, rotational grazing, and intensity of grazing and the production of forage on the range.

b-2-3-2 - Pasture management with sheep using soybeans, oats, wheat, barley, rye, and permanent grass mixtures. To determine types of forage and mixtures of permanent grass best suited to the production of continuous and high quality pasturage for sheep and lambs in the eastern region of the United States.

b-2-3-4 - Development of improved sheep branding fluids. To develop a sheep branding fluid that will remain legible and at the same time scour out of the wool by current mill scouring processes.

C. History and Evolution of This Work

Economic and effective management of the ranges and farms on which sheep grow is so necessary to the success of both the wool-growing and meat-producing phases of the industry that sheepmen early recognized the need for sound, practical advice based on research. As the rangelands for sheep shifted ever westward at the beginning of the century, aid was sought from the Bureau in solving problems evolving from pasturing in areas of light rainfall, changing topography, and varying forages. This project, accordingly, was started in 1906 with range sheep at Laramie, Wyo. and with farm sheep in 1909 at Middlebury, Vt. Additional studies of management of farm sheep were started at Beltsville, Md. in 1915, and at Newell, S. Dak., management under irrigation farming conditions has been under research since the early 1920's. At Dubois, Idaho and at Miles City, Mont. varying conditions peculiar to sheep ranges in those areas are studied to develop most efficient practices that can be used by the industry.

D. Funds -- Annual Expenditures

With management investigations financed from funds covering several lines of research with sheep and goats, estimates in early years are difficult to obtain. Direct expenditures for all sheep and goat husbandry investigations varied from about $80,000 in 1923 to about $84,700 in 1934 and averaged slightly over $88,000 annually. During this period there were expenditures for three projects (maintenance of Beltsville station and fundamental research on animal genetics and nutrition) for which no basis for distribution is available now. The average annual expenditures for these three projects from 1923 to 1934 was about $92,000 annually. The direct costs for sheep management investigations varied from about $13,600 in 1935 to about $13,500 in 1943. Expenditures have ranged from about $13,000 in 1944 to $20,100 in 1950.

E. Examples of Outstanding Accomplishments

Development of a system that would provide good forage for sheep, especially ewes and their suckling lambs, when permanent pasture of bluegrass and similar forages were sparce or dormant in the hot summertime. Such temporary pasture also supplements permanent pastures in seasons when growing lambs make increasing demands for good succulent feed. These temporary pastures have been primarily rye, wheat, barley, oats, peas, and soybeans. This system insures for sheepmen an opportunity to keep sheep and lambs in a gaining condition at a critical time of the year, when absence of such forage would result in losses in thrift and necessary gaining in weight for profitable production of market lambs.

Proof that spring grazing with sheep on spring-fall intermountain sagebrush grass ranges is best managed when started after grasses reach a two-inch height growth. It was found that there is a minimum of variation in this stage of grass development, thus insuring available range forage in most years and necessitating the maintenance of not more than a ten-day supply of reserve feed for the exceptional year when forage development is late. This practice in management also precludes misuse of the range, since, from this time on, forage growth was found to progress ordinarily in advance of the sheep, insuring that adequate feed will be available during the entire spring season if the range is not overstocked.

Determination that fall grazing with sheep is best started on the sagebrush grass ranges when the forage on the high summer ranges is utilized, but preferably after rains start regrowth of grasses or soften the cured bunch grasses. Since the fall grazing must end with the coming of deep snow, and its occurrence is extremely variable, it was found that a thirty-day reserve supply of feed or its equivalent of protected winter range over and above the normal winter requirements should be maintained as insurance against years of early snow.

Finding that stocking sagebrush grass ranges with sheep is satisfactory at the rate of two-thirds of a sheep per acre per month for approximately two and one-half months in the spring and again in the fall where the plant cover was about 25 percent, comprising approximately 45 percent bunchgrass and palatable weeds, and 55 percent of sagebrush and other less palatable shrubs.

Discovery that rotation spring grazing with sheep is essential for maintaining sagebrush-bunchgrass range under the conditions of climate prevailing in the intermountain area. Results showed that this system of grazing sheep can be applied by dividing the range into two or more convenient units and routing the sheep from one to the other as the season advances, beginning the process with a different unit each succeeding year. This practice insures adequate forage in the poorest forage growth years and in good years permits range plants which may have been heavily grazed in previous years to recover vigor. Because ample forage is available, sheep can be maintained in a thrifty and productive condition.

Determination that carefully planned burning, when properly carried out, is an effective means of increasing good sheep forage production on range lands. This practice serves to remove dense stands of sagebrush effectively, and without damage to range pastures.

Proof that breeding Hampshire ewes for the first time as lambs at 18 to 19 months results in a material increase in their total lamb production over their entire breeding span. Tests were made under irrigation farming conditions with good feed and environment for adequate development of the ewe lambs. The results also showed that the ewes bred as lambs were not injured as mothers of good lambs or as wool producers by this early motherhood.

Discovery of a green tattoo ink that is excellent for maintaining the identity of breeding sheep, even sheep having pigmented or colored ears as dark as the ears of Hampshire and Shropshire breeds. This has solved an important problem of breeders and importers of purebred registered sheep who find it essential to maintain the individual identity of valuable sheep used in improvement programs by the application of intensive breeding methods.

Development of a durable and scourable sheep branding paint that will maintain the identity of sheep for a year on western ranges, and that will completely scour out of the wool in the usual mill scouring procedures. Further improvement is being worked out for this paint to keep it sufficiently liquid at relatively low temperatures so that it can be applied by shepherds who often have to brand sheep in rather cold weather.

F. Some Additional Work Needed

Development of practical systems of combining sheep and cattle grazing for maximum economic returns per acre is needed and requires intensive research. On most pastures and ranges some forage is more suitable for cattle than for sheep and some forage can be used to best advantage by sheep only. Studies of possible rotation methods or some other means of grazing sheep and cattle on the same pastures are needed to make complete use of all available forage and produce greater financial returns per acre of land.

Development of more nutritious, palatable, and productive forage for sheep on winter ranges and more effective methods of management to reduce costs of feeding range breeding sheep in winter feed lots, requires research. The high cost of winter feeding from stack, mow and bin is a constant threat to the industry's economy.

COCCIDIOSIS OF SHEEP, GOATS, AND SWINE
(BAI No. c-5-3 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

To obtain information (1) on the life histories of coccidia (intestinal parasites) in sheep and goats, and (2) on the effect of single species of coccidia on the health of the host animal. The nature of the current work is purely experimental. It is designed to form a basis on which to develop methods of controlling coccidiosis, the seriously debilitating and widespread disease caused by this parasite.

B. Currently Active Line Projects

c-5-3-2 - Investigations of life histories of coccidia of sheep and goats, and of control measures. To obtain information on the life cycles of coccidia infecting sheep and goats, to determine the injury produced by these parasites, and to develop control measures.

C. History and Evolution of this Work

Various species of coccidia occur in sheep and goats. Ordinarily they are found in small numbers, and the infected animals show no evidence of their presence. When they occur in large numbers, however, they produce marked intestinal disturbance manifested by severe, and at times bloody, diarrhea. Specific work designed to obtain information on these parasites and their effect on the health of the animals that harbor them began about 1937. At that time a special investigation was made of lambs in a feed lot infected with coccidiosis, a large number of these lambs having died of the disease. Investigation showed that the animals were suffering from coccidiosis spread largely through the contamination of silage in the feed troughs with the feces of animals in the feed lot. Many species of coccidia were found in the affected animals, but it was not known which were primarily responsible for the injury and death of the animals. Further experimental work showed clearly that these species of coccidia differed in their location in the intestine, in their method of reproduction, and in the injury they produced. As a result of this field experience, and of limited experimental work, it became evident that the life history and injury-producing capacity of each species must be determined before a rational approach to treatment or prevention can be made. The current work is founded on this need.

D. Funds--Annual Expenditures

Research on coccidiosis of sheep and goats was initiated in the fiscal year 1937 and was included with other parasitological studies under the project "Investigations of internal parasites of ruminants." Direct expenditures for that project ranged from $21,800 in 1937 to $24,400 in 1941. In 1942 a new project covering studies of coccidiosis of sheep and goats, as well as swine, was established. Expenditures under it ranged from $9,500 in 1942 to $13,900 in 1950.

E. Examples of Outstanding Accomplishments

Demonstration that coccidiosis of feed-lot lambs can be prevented even though silage is used as part of the rations. Previously it had been believed advisable to discontinue the use of silage as a fattening ration for feed-lot lambs in order to remove the moist food as a dangerous source of coccidia infection, and to replace it with the more expensive dry rations. Now it has been demonstrated that silage can be used safely if it is protected from contamination with droppings of lambs infected with coccidia. This knowledge represents a considerable saving to the feeder in providing effective control measures against coccidiosis.

F. Some Additional Work Needed

Relative effects of infestations on sheep and goats. It is reasonable to suppose that some species that are harmful to sheep are relatively harmless to goats and vice versa. However, specific facts are necessary before control methods can be established.

Length of life of the resting phase of the parasite on pasture and its ability to withstand varying conditions of temperature and moisture are important considerations in the development of control methods. Little information is available on these subjects.

WORM PARASITES OF SHEEP AND GOATS
(BAI - No. c-6-2 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

(1) To determine the life histories of worm parasites of sheep and goats and the effect of infestation with these worms, and (2) to develop preventive measures based on the life histories. The current work is particularly concerned with the thread lungworm of sheep, *Dictyocaulus filaria*, which is widespread in sheep producing areas and causes severe loss of condition and frequent deaths among heavily infested animals.

B. Currently Active Line Projects

c-6-2-6 - Investigations on the life history of the thread lungworm of sheep and goats and its ability to cause disease. To determine the life history of this lungworm, the effects of temperature and moisture on development of the larvae and their survival on pasture at different seasons of the year and the effect of lungworms in the absence of other parasites or disease organisms.

C. History and Evolution of This Work

Worm parasites have long been recognized as the cause of serious diseases of sheep and goats. As early as 1891 it was discovered that nodular disease of sheep was caused by a roundworm, and that the disease was not some form of tuberculosis as had been supposed. The realization that worms differed in their effect on animals led to experiments to determine the precise effects of single species of worms. As a result of these experiments the discovery was made that some worms spend a part of their life cycles on pasture, with no intermediate host involved. This information formed the basis for the establishment of the current project in 1936.

D. Funds--Annual Expenditures

With these investigations financed from funds covering work on several lines of research, estimates for early years are difficult to obtain. However, direct expenditures from regular funds for all research on parasites and parasitic diseases of animals and poultry averaged $112,000 annually between 1923 and 1935 and $172,000 between 1936 and 1941. Expenditures have ranged from about $15,000 in 1942 to $24,500 in 1950.

E. Examples of Outstanding Accomplishments

Recognition of the eggs of the different kinds of worms commonly found in sheep and goats. Sheep and goats are commonly infested with a number of different worm parasites. They reproduce by means of eggs, which are found in the droppings. Although these eggs are extremely small and those from the different worms are, for the most part, similar in size and shape, it is now possible to separate and identify eggs of the different species of worms with reasonable certainty and accuracy. This accomplishment has

has resulted in more definite and accurate determination of the identity of the parasitic disease affecting an animal; it has helped to evaluate the effectiveness of drugs used as worm removers; and it is of major importance in planning treatment and control measures.

Determination of the life expectancy of parasites on pasture, making it possible to recommend grazing practices aimed at parasite control. Even in areas where sheep are kept on pasture during the winter, little danger has been found of their becoming seriously infested with parasites because, with one or two exceptions, parasite eggs fail to develop at winter temperatures, Furthermore, it has been found that eggs on pasture do not survive long periods of dryness or limited rainfall and that most of the larvae die during the winter, leaving the pastures relatively free of infection in the spring. Even when climatic conditions are favorable for development of eggs and survival of larvae, most infective larvae have been found to die in 6 to 12 weeks.

Experimental studies with the sheep tapeworm (Moniezia expansa) have shown that this is not as serious a parasite as it has been generally supposed to be.

F. Some Additional Work Needed

Lungworms of sheep and goats. Two of the three kinds of lungworms in sheep and goats in the United States require snails as intermediate hosts in their life cycles, but little information regarding these snails is available. In order to develop effective methods of controlling these lungworms, research is needed on the identity of the snails, their habitats, and the conditions under which they thrive.

Relation of animal nutrition to parasitism. There is some evidence that well-fed animals are better able to cope with common parasites than poorly nourished animals. However, far more information than is now available should be obtained on the effect of nutrition on an animal's reaction to parasites.

A more comprehensive study of parasites in the different areas of the United States. The different climatic conditions in different parts of United States present separate problems in dealing with worm parasites of sheep and goats. The results of experiments conducted in one section do not necessarily apply in another section with completely different climatic conditions. Therefore, the areas need to be studied separately to find effective parasite protection methods for each section.

Methods by which parasites produce their injuries. Worm parasites of sheep and goats produce different types of injuries. For instance, stomach worm produce a marked and frequently fatal anemia in many animals; the small intestinal worms cause diarrhea and unthriftiness. More information on the different methods of attack by parasites is important in the development of control measures.

Effects of parasites on different species of animals. The assumption that the results of experimental work with one species of animal apply to other species may be correct in some instances, but in many cases it is completely erroneous. For example, goats are much more severely affected by the small intestinal worms than are sheep, and sheep and goats both suffer more from liver fluke infestation than do cattle. More research on this problem is needed.

INFECTIOUS AND NONINFECTIOUS DISEASES OF FUR ANIMALS
(BAI - No. c-9-1 - Federal-Regular Funds)

A. Purpose and Nature of Current Work

To investigate the cause, means of transmission, and methods of control of diseases of pen-raised fur animals, including rabbits. The current work includes experiments on distemper in foxes and minks and on so-called yellow fat or watery hide in minks. In addition, in cooperation with fur farmers in strategic areas, studies are being made of major disease outbreaks on fur ranches to obtain information on the nature and control of other important diseases of minks and of diseases of chinchillas. An investigation of the hazard of food poisoning from feeding uncooked poultry waste to minks is also being made. Facilities are now available for conducting research on diseases of domestic rabbits.

B. Currently Active Line Projects

c-9-1-2 - Distemper in foxes and minks. To develop a specific blood test for diagnosing distemper, to determine the effectiveness of various mink and fox vaccines on the market, and to find an effective method for treatment of the disease.

c-9-1-3 - Yellow fat (nonsuppurative panniculitis) in minks. To determine the conditions that cause yellow fat in minks and to develop practical methods of preventing the disease.

C. History and Evolution of This Work

In response to increasing recognition of the possibilities of fur farming as an industry, the Federal Government began experimental work on fur farming in 1912 and reported findings in 1916. Observations on fur-animal diseases were made at the United States Fur Animal Experiment Station from 1916 to 1924 while it was located at Keesville, N. Y. and later at Saratoga Springs, N. Y. Cooperative research investigations in the Midwest from 1927 to 1939 yielded valuable information on important diseases in foxes, such as distemper, Chastek paralysis, and paratyphoid infection; also on tumors and tularemia in rabbits and other fur animals. Studies on rabbit diseases including bloat, septic infection, and infectious tumors were made at the Rabbit Experiment Station at Fontana, Calif., beginning in 1932. In 1939 the functions of the Bureau of Biological Survey which included research on fur animal diseases, were transferred from the Department of Agriculture to the Department of the Interior, but in 1946 all activities pertaining to pen-raised fur animals including domestic rabbits were brought back to the Department of Agriculture.

D. Funds--Annual Expenditures

Expenditures for research on infectious and noninfectious diseases of fur animals since the transfer of the activity to the Bureau of Animal Industry have been as follows:

Fiscal year 1947 - $33,900
Fiscal year 1948 - $33,300

Fiscal year 1949 - $34,400
Fiscal year 1950 - $38,500

E. Examples of Outstanding Accomplishments

Development of a rapid laboratory method of diagnosing distemper in fur animals. By this method, a dependable diagnosis can be made on the same day that specimens are received (provided two or more carcasses are examined) as compared with 2 or 3 weeks necessary with the ferret susceptibility test formerly used. This prompt diagnosis of a disease often results in saving many of the remaining healthy animals on the premises through early control and eradication measures.

Discovery of causes of outbreaks of a contagious form of brain inflammation in foxes and development of control methods. Control of this disease has avoided considerable losses to fox raisers in some areas.

Finding means of preventing and curing a disease of minks known as Chastek paralysis. The cause of this disease was found to be a vitamin B_1 destroying factor contained in certain fish and fish byproducts. Consequently, supplying vitamin B_1 to the diet in some form avoids losses from this disease in regions where fish or fish byproducts are the principal part of the diet.

Finding that lead poisoning will occur in minks if the cages are painted with red lead.

Discovering that excess quantities of salt in the diet--3 percent of the ration as fed--will kill minks. Any feeds containing excessive amounts of salt, therefore, should not be included in the mink diet.

F. Some Additional Work Needed.

Determination of the causes and development of methods of prevention and treatment of enteritis in mink. The disease is found wherever minks are raised. Salmonella organisms are believed to be the cause of enteritis although this has not been proved experimentally. Research on this point is needed if effective control measures of enteritis are to be developed.

Effective methods to protect chinchilla raisers against outbreaks of two rare diseases that have caused heavy losses in recent years.

Determination of the practical value of vaccination against botulism, or food poisoning, in mink. Some mink raisers are having difficulty in preventing losses from such poisoning.

Determining the conditions responsible for bloat in rabbits and developing measures for preventing and treating this disease. Bloat is one of the principal causes of domestic-rabbit mortality.

PARASITES AND PARASITIC DISEASES OF FUR ANIMALS
(BAI - No. c-9-2 - Federal-Regular Funds)

A. Purpose and Nature of Current Work

To obtain the necessary basic facts for developing measures of parasite control in fur animals, and to supply such information to breeders of these animals. Current work is concerned with three specific parasites causing serious diseases in rabbits—coccidia, pinworms, and ear mites.

B. Currently Active Line Projects

c-9-2-1 - Effects of hutch-floor construction on coccidiosis in domestic rabbits. To learn more about how domestic rabbits acquire coccidia—a serious parasite—and to find better ways of designing rabbit hutches to help prevent the animals from contracting coccidiosis, the disease caused by the parasite.

c-9-2-2 - Life cycle and practical control of pinworms of domestic rabbits. To find practical means of raising rabbits that will prevent their acquiring these parasites.

c-9-2-3 - Control of ear mange in domestic rabbits. To develop a practical and effective treatment for controlling and curing ear mange in rabbits, caused by ear mites, which are among the most injurious external parasites of domestic rabbits.

C. History and Evolution of This Work

During the past four years work on parasites of fur-bearing animals has been centered exclusively on the parasites of rabbits, largely because they are important food animals for man. Before 1946 activities in this field were under the supervision of the Department of Interior, where some sporadic work was done on the control of fox parasites.

D. Funds--Annual Expenditures

Expenditures for research on parasites and parasitic diseases of fur animals since the transfer of the activity to the Bureau of Animal Industry have been as follows:

Fiscal year 1947 - $14,500
Fiscal year 1948 - $17,200
Fiscal year 1949 - $16,100
Fiscal year 1950 - $16,200

E. Examples of Outstanding Accomplishments

The complexity of the problems has been such that no outstanding accomplishment can be reported for the short period the project has been organized along current lines. The most promising result so far is the following:

Determination that benzene hexachloride is an effective and economical treatment for the control and/or eradication of ear mange of rabbits. During 1950 benzene hexachloride was discovered to be the most effective and economical treatment that has been found for the destruction of ear mites which cause ear mange in rabbits.

F. Some Additional Work Needed

Development of practical control measures for lungworms in foxes. The fox lungworm is one of the most difficult parasites to control. No known medicinal treatment is effective against it, and control must be based on management. Therefore, it is important to learn more about the parasite itself so that producers can be given practical recommendations about ways to avoid its spread and the attendant loss of condition and frequent deaths among foxes.

Prevention and control of worm parasites of minks and related fur animals. The most injurious worm parasites of minks and related animals are acquired through the eating of fish. Research is needed to determine methods that will destroy the larval stages in fish and thereby prevent the animals from acquiring these parasites.

SHEEP PARASITE INVESTIGATIONS IN WESTERN RANGE STATES
(BAI - RM-b-40 - Federal - State - RMA Funds)

A. Purpose and Nature of Current Work

To obtain information on the life cycles, disease-producing ability, distribution, and other problems concerning internal parasites commonly infecting sheep in the Western Range States. This information provides a basis for effective methods of controlling such parasites and the diseases caused by them in sheep. The current work particularly involves investigations on (1) the life cycle of the liver tapeworm, as control measures cannot be developed until the mode of transmission of this parasite has been discovered; (2) the life cycle and disease-producing ability of the intestinal threadworm; (3) the relation of this parasite and others including the intestinal tapeworm, to dysentery; and (4) the development of methods of prevention, control, and treatment of this condition.

B. Currently Active Line Projects

RM-b-40(1) - Life history of the fringed tapeworm of sheep and methods of control. To find the mode of transmission and trace the life cycle through the various hosts; to determine what steps can be taken to prevent sheep from acquiring this parasite through controlling the intermediate host or hosts, once these are discovered.

RM-b-40 (2) - The relationship between internal parasites and dysentery of sheep. To determine the species of parasite or parasites that cause dysentery in lambs; to discover the factors that make them susceptible to such dysentery; and to develop methods for controlling the parasites and treating the disease caused by them.

C. History and Evolution of This Work

Considerable work has been done during the last 50 years to learn more about parasitic diseases of sheep and how to control them. These studies have shown that sheep raised in different regions of the country are subject to various parasitic problems peculiar to the region. As an outgrowth of such findings, this special Federal project was set up in 1948 to study the sheep parasites and parasitic diseases of the Western Range States, where a large proportion of the sheep of the United States are produced.

D. Funds--Annual Expenditures

This special work was initiated in the fiscal year 1948. Expenditures for this research have been as follows:

Fiscal Year 1948	$20,300
Fiscal Year 1949	24,500
Fiscal Year 1950	30,200

E. Examples of Outstanding Accomplishments

Since this project has been in existence for slightly less than 3 years, and some time was spent in obtaining personnel, establishment of laboratories, and purchase of equipment and supplies, outstanding accomplishments are limited.

Relation of the intestinal threadworm of sheep to dysentery. It was found that the intestinal threadworm alone, when present in lambs in large numbers, can cause acute dysentery. This condition is characterized by profuse watery diarrhea, marked weight loss, emaciation, and sometimes death. The immature parasites were found to be the most injurious. They destroy the inner lining of the small intestine during their period of growth, and this results in a great loss of fluid from the animals and serious disturbance to digestion and absorption. Therefore, the intestinal threadworm, heretofore considered to be of minor importance as an injurious parasite, definitely should be added to the list of parasites capable of causing dysentery in lambs in areas where it is common.

F. Some Additional Work Needed

Evaluation and control of parasites and parasitic diseases of range sheep and sheep raised on irrigated pastures in the Western States. As the acreage of irrigated land increases in the West, more and more sheep are being raised on this land. Furthermore, in some areas range lambs are placed on irrigated pasture to fatten. Consequently, parasitic diseases are greatly intensified because moisture and other conditions are very favorable for the transmission of many of the parasites. There is a rapid build-up of heavy infections, which cause extensive losses. However, little information is available on the relative importance of various kinds of parasites affecting sheep on irrigated pasture, as compared with those affecting range sheep. Answers are needed to such questions as the following: To what extent and how rapidly does the parasite population change in these lambs? What are the important parasites of sheep on range and irrigated pasture? How can these parasites best be controlled?

FUR-ANIMAL PHYSIOLOGY OF REPRODUCTION
(BAI - No. b-8-2 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To determine the physical characteristics of the reproductive tracts and germ cells of pen-raised fur animals and their relation to artificial insemination; to study any and all factors that influence the reproductive capacity of these animals particularly during the fertilization period. The ultimate objective is to increase the litter size and the percentage of pregnancies. Current work includes studies of the effects of artificial lighting on breeding seasons, development of methods of successful artificial insemination, and improvement of management practices.

B. Currently Active Line Projects

b-8-2-1 - Mink reproduction. To develop management practices that will aid in increasing the number of pregnancies and in producing large litters of minks; to develop methods of successful artificial insemination.

b-8-2-2 - Effects of artificial lighting on breeding efficiency of fur animals. To determine the relationship between hours of daylight and the breeding season in different species of fur animals, particularly martens and minks.

C. History and Evolution of This Work

Breeding problems of fur farmers, involving small size of litters and a large percentage of progeny losses, menaced the youthful industry to such an extent that, with State cooperation, the Bureau of Biological Survey of this Department began this project in 1932. Since little was known of the reproductive organs of wild animals or even of their breeding habits, early research was concentrated on determining the physical characteristics of their reproductive tracts and germ cells. Such findings were considered imperative as the reticence of the animals to breed in captivity was an ominous threat to the industry. On the basis of results of that research, experiments were begun to establish methods of insuring normal and healthy litters of young through a higher percentage of matings and pregnancies. Techniques for collecting semen by electrical stimulus were perfected, and attempts to inseminate foxes artificially were successful.

In 1939 all activities of the Bureau of Biological Survey, including fur-animal investigations, were transferred to the Department of the Interior. In 1946, this research work was returned to the Department of Agriculture.

In 1947, limited research on the physiology of reproduction was begun cooperatively with a north central State. More recent lines of approach to these problems have been on the hormone relationships to fertilization of the animals and resorption of the embryos. Of particular interest has been the possible effect of the hormone diethylstilbestrol, the residue of which may be found in chicken waste of "caponettes," (chemically castrated chickens) when fed to minks.

D. Funds--Annual Expenditures

Expenditures for this project since its transfer to the Bureau of Animal

Industry have been as follows:

F. Y. 1947	$19,000
F. Y. 1948	21,000
F. Y. 1949	23,800
F. Y. 1950	14,500

E. Examples of Outstanding Accomplishments

Discovery that attachment of the embryo to the uterus shortly after fertilization of the egg may be delayed for extended periods in minks, martens, and fishers. It was found that seasonal changes in daylight are largely responsible for this phenomenon. This explanation of delayed births will be the basis for future studies to improve size of litter and number of pregnancies--factors so vital to the economy of the industry.

Perfection of an electric stimulator for collecting semen. This is the first step in artificial insemination, which has proved so beneficial in other animals.

Determination of the nature and time of ovulation (the proper time for breeding) in the fox and the time and process of fertilization. This information permits the establishment of better breeding schedules on fur farms, which will result in increased numbers of litters.

F. Some Additional Work Needed

Determination of the safe limits and time of the year when poultry waste from chemically sterilized birds can be fed to minks and foxes. Tons of this cheap fur animal feed are available and the quantity is increasing. There is some indication, however, that when such waste is fed to these animals during the breeding season it affects their breeding efficiency. Specific research is needed to determine extent and nature of the effects of the chemical (diethylstilbestrol) in poultry waste on both male and female wild animals on fur farms.

Improving techniques in collecting semen and inseminating minks and foxes artificially. Influence of superior sires can then be extended many fold. The reproductive systems and their normal functioning are quite dissimilar to those of other livestock.

Physiology of reproduction in martens. At present only about 15 percent of female martens of breeding age produce young. This fur animal is becoming scarce in the wild and once this infertility has been eliminated marten ranching will become profitable.

REPRODUCTION AND LACTATION IN GOATS
(BAI - SRF-2-116 - Federal-Special Funds)

A. Purpose and Nature of Current Work

To extend, if possible, the breeding season of goats so that milk can be produced throughout the year. To determine the normal anatomy of the reproductive tracts of male and female goats at various stages of sexual development and activity. Current work, all of which is directed toward the final objective of a continuous milk supply, deals with experiments on the effect of variation in the length of day on the breeding season, value of palpating--or examining by feeling--the udders of immature does to predict later milk production, and the effect of physiological changes on reproduction and lactation.

B. Currently Active Line Projects

The work of this special project is not divided into line projects.

C. History and Evolution of This Work

Invalids, infants, and persons having some forms of stomach trouble frequently benefit from diets containing goat's milk. Normal breeding seasons of the animals, however, result in such milk supply being very short for 3 or 4 months of the year. This project was begun in 1947 to study means of extending the breeding season and providing an increased and continuing milk production. Experiments have been continued for 3 years. To study the influence of variation in the length of day on the estrus, or heat period, test rooms equipped with automatic clocks for light control have been constructed. Incidental to this work, a few sheep have been used in the experiment for comparison of results.

D. Funds--Annual Expenditures

The expenditures for this project have been as follows:

Fiscal year 1947 -	$10,300
Fiscal year 1948 -	7,000
Fiscal year 1949 -	8,800
Fiscal year 1950 -	10,500

E. Examples of Outstanding Accomplishments

Determining that out-of-season breeding in goats depends on length of day. During 1948-49, at Beltsville, 93 percent of does under controlled lighting produced out-of-season kids, whereas only 25 percent of does under normal lighting produced kids out of season. Does in the light-controlled groups were divided into two 13-week periods of conditioning which simulated the different seasons of the year. A period of 18 hours of light daily, which is similar to summer conditions, was followed by 6 hours of light daily, comparable to winter. This shifting of the breeding season will make possible the production of milk throughout the year instead of seasonally as under the present systems of breeding.

Discovery of no definite seasonal trend in the volume, motility, and concentration of semen from bucks, and in the percentage of abnormal spermatazoa. This finding indicates that as far as the rams are concerned goat breeding can be conducted at any season of the year.

F. Some Additional Work Needed

The possibility of shifting the normal breeding season has indicated need for various phases of research such as determination of the practical spread of hours of light and darkness to condition goats for out-of-season breeding; whether the same goats can be used for spring and fall matings or whether it would be necessary to divide the herd; the effect of out-of-season birth on the weight, vitality, and growth of the kids; the necessity for conditioning bucks for out-of-season breeding; and detection of length of estrus so that hand matings versus pen matings could be made.

CROSS REFERENCES - Production

For additional information especially pertinent to subjects reported on in this chapter, see also:

BAE - A-1-23, Chapters 1 and 24, cost of producing sheep.
BAE - SRF-2-115, Chapter 24, feed output relationships for livestock.
BAI - c-2-5, Chapter 1, miscellaneous diseases of livestock caused by bacteria and fungi.
BAI - c-4-1, Chapter 31, stock poisoning by plants.
BAI - c-4-4, Chapter 1, miscellaneous non-infectious diseases of livestock.
BAI - c-6-4, Chapter 1, liver flukes.
BAI - c-7-1, Chapter 31, parasites of food animals.
BAI - c-7-2, Chapter 31, parasites of dogs, wild animals, and birds transmissible to livestock.
BAI - c-7-3, Chapter 1, parasite collection.
BAI - c-8-1, Chapter 31, external parasites.
BAI - c-8-2, Chapter 1, internal parasites.
BAI - h-1, Chapter 35, inspection and quarantine of imported animals.
BAI - i-4-1, Chapter 1, chemical and nutrition investigations.
BAI - m-2, Chapter 35, enforcement of Mexican border quarantine for foot-and-mouth disease.
BAI - m-3, Chapter 35, inspection for foot-and-mouth and other animal diseases.
BAI - Control of virus, serums, etc., Chapter 35.
BAI - Laboratory services for regulatory, control and eradication programs, Chapter 35.
BAI - SRF-3-7, Chapter 1, diseases of animals.
BAI - RM:a-371, Chapter 8, feeds.
BAI - RM:a-508, Chapter 8, pelleted feeds for livestock and poultry.
BAI - RM:a-560, Chapter 1, feeding of wheat to livestock.
BAI - RM:b-332, Chapter 1, grass poisoning.
BAIC, BAI, BDI - RM:a-307, Chapter 14, feeding waste products to livestock and poultry.
BDI, PMA, BAI - RM:c-273, Chapter 8, comparative value of hays with different nutritive values.
BEPQ - I-h-2, Chapter 31, flies attacking livestock
BEPQ - I-h-3, Chapter 1, grubs and bots attacking sheep.
BEPQ - I-h-4, Chapter 1, studies on lice, mites, and fleas.
BEPQ - I-h-5, Chapter 31, tick investigations.
BEPQ - Survey of the screw-worm, Chapter 31.
BEPQ, BAI, BDI, BPISAE, BAIC - RM:b-72, Chapter 31, effects of insecticides, etc.
BPISAE - e-2-2, Chapter 30, livestock and poultry shelters.
BPISAE - SRF-3-10, Chapter 22, relation of soils and nutritional content of forage to nutritional troubles in animals.
BDI, BAI - RM:a-7, Chapter 8, availability of nutrients in forage.

MUTTON AND GOAT MEAT
(BAI - No. b-2-7 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To (1) determine and evaluate the effect of breeding and other production factors on the characteristics of dressed carcasses and the quality of lamb, mutton, and goat meat; (2) the basic factors involved in the preservation and storage of lamb; and (3) the characteristics of sheep and goat carcasses associated with the various market classes and grades as a basis for improving grade standards. To develop improved methods for evaluating the characteristics of slaughter sheep and goats, their dressed carcasses, meats, and meat products. The current work relates particularly to the study of meat from lambs representing certain breeds and crosses, which involves study of the inheritance of tenderness and other important meat factors. Work is also in progress on the factors affecting the preservation of lamb and mutton.

B. Currently Active Line Projects

b-2-7-2 - Requirements for successful storage of cured lamb. To develop methods of storing cured lamb that will prevent the development of a hard, dry condition and excessive mold growth and will retain acceptable flavor.

b-2-7-3 - Inheritance of tenderness in meat. To determine the degree of heritability and the mode of inheritance of tenderness.

b-2-7-4 - Meat characteristics of lambs representing certain breeds and crosses. To effect improvement in yield of preferred cuts, tenderness, ratio of lean meat to bone, and other meat characteristics of lambs through studies on certain breeds and crosses.

C. History and Evolution of This Work

In the early 1920's, sheepmen faced problems of improving the palatability and grades of lamb meat to meet consumer demands. Therefore, when the Bureau began this project in 1926, as an aid to sheep growers, it dealt with rather general comparisons of those qualities of the meat as affected by breeding and feeding. Considerable attention was also devoted at that time to comparative studies on ram and wether lambs. The first processing study in the middle 30's dealt with the effects, on the palatability of the meat, of aging lamb legs in cold storage, and this was followed by research on curing and the storage of cured meat. Prominent among other lines of work was the study directed toward the characterization of the commercial grades of lamb carcasses in definite measurable terms. Still other examples of research, as the work continued, were determination of the quality of "hot-house" lambs, development of dehydration methods during the war emergency, inheritance of tenderness, and the nutritive value of the protein from the leg and other cuts of the lamb carcass. One of the later important additions to the research dealt with effects of freezing and freezer storage on quality of the product. Throughout the work similar studies were made of goat meat.

LIBRARY
UNIVERSITY OF ILLINOIS

D. Funds--Annual Expenditures

Estimates for early years are difficult to obtain because there was one project covering studies of beef, pork, mutton, and goat meat. Direct expenditures for meats work varied from about $26,000 in 1926 when mutton and goat meat studies were initiated to $29,000 in 1934. Direct expenditures for mutton and goat meat studies have ranged from about $19,000 in 1935 to about $21,000 in 1943. In 1942 and 1943 emergency funds were made available to the Department for meat dehydration studies, certain phases of which were conducted by the Bureau. The total expenditures for those meat dehydration studies were approximately $16,000 and $123,000, respectively. Expenditures for this mutton and goat meat research have ranged from about $21,000 in 1944 to $10,000 in 1950.

E. Examples of Outstanding Accomplishments

Discovery of the high value of good pasture for lambs running with their dams. Practically no difference in slaughter-animal or dressed-carcass grade was found between lambs fed grain while running with their mothers on good grass pastures and others fed no grain. This finding proved that it was unnecessary for sheepmen to fatten lambs on grain, with resulting savings in feed costs.

Development of new methods for carcass evaluation. The composition of the rib cut was found to be highly representative of the composition of the entire dressed carcass and can be used satisfactorily for estimating the composition of the latter. Dietitians and others concerned with large-scale feeding problems are finding increasing use of this procedure. Moreover, there are strong indications that the yield of preferred cuts, including legs, loins, and ribs, can be used advantageously by the scientific breeder for evaluating different lines of breeding with regard to their meat composition.

Development of reliable method for measuring meat tenderness. A thoroughly reliable laboratory method for measuring tenderness, wholly independent of human judgment, was necessary before any study involving that factor of palatability could be carried out satisfactorily. A device was developed that measures the force in pounds required to shear a cylindrical sample of the cooked meat being tested. Results obtained with this device correlate well with human judgment of tenderness but are free from the variability imposed by differences in opinion among several judges. The apparatus is applicable to other kinds of meat as well as to lamb, mutton, and goat meat.

Discovery of the heritability of tenderness. With the use of rabbits as experimental animals, certain strains were identified that, on the average, produced tender meat and other strains that, on the average, produced tough meat. These results and subsequent data relating to the crossing and back-crossing of the strains are regarded as justifying similar experiments to determine like heritable tendencies in farm meat animals.

Development of a method for curing lamb that yields a very desirable smoked product. The method consists in a variation of the conventional sweet pickle curing procedure, followed by smoking as used in curing hams.

Discovery that frozen lamb, when vacuum packed, keeps as well at 18° as at 0° F. Indications, therefore, are that the higher, less costly temperature may be used instead of the generally recommended temperature of 0° provided most of the air is removed from the container.

F. Some Additional Work Needed

Effects of breeding and crossbreeding of sheep and goats on meat quality. Preliminary research indicates that yields of dressed carcasses and proportions of different cuts are especially affected by crossbreeding. Likewise, tenderness of meat may be associated with various strains, and other variables may also be involved. Intensive research in this field should result in improvement in meat quality.

The reaction of lamb meat to air in freezer storage is an example of problems in the low-temperature preservation field that need further study. Such a study would involve various degrees of exclusion of air from the meat, different freezing temperatures, and other factors, in order to develop better and perhaps more economical methods for preserving flavor in frozen lamb and mutton.

The use of new techniques, such as ultrasonic (high-frequency sound waves) and cathode ray irradiation to inactivate enzymes and bacteria and to promote other desirable changes in foodstuffs, has been frequently mentioned. Research on the application of these and similar techniques to meats is urgently needed.

DEVELOPING NEW AND IMPROVED USES FOR WOOL

(BAIC - RM:a-141 Federal - RMA Funds)

A. Purpose and Nature of Current Work

To lay the basis for modification of the characteristics of domestic wools and mohair, thus enabling them better to meet competition from foreign wools and synthetic fibers is concerned with a determination of the physical properties of natural wool and mohair fibers as a basis for determining what changes take place when the fibers are subjected to chemical treatments to produce specific modification of them.

B. Currently Active Line Projects

RM:a-141-1 - Physical investigations of natural and modified wool and mohair fibers. To determine the physical properties of wool and mohair fibers by optical, x-ray, and electrical methods in order to provide a basis for greater commercial utility of these fibers.

RM:a-141-2 - Modification of wool and mohair fibers by chemical means. To modify wool and mohair fibers by chemical treatment in order to improve their desirability in textiles or other fiber applications.

RM:a-141-3 - Mechanical and molecular-kinetic characterization of natural and modified wool and mohair fibers. To lay the basis for the development of wool and mohair fibers having more uniform and superior textile and fiber characteristics and for more profitable utilization of waste wool and mohair, through mechanical and molecular-kinetic investigations of wool, mohair, and their derivatives.

RM:a-141-4 (c) - Effect of subjecting wools to moist air for various periods of time in various stages of processing upon the quality of worsted fabric obtainable from them (Contract with a private textile research organization). To determine conclusively whether worsted fabrics of significantly higher quality can be produced from medium-grade wools through the introduction of controlled delays between various steps in the processing; if so, to devise means for accelerating the desirable changes so as to minimize the actual time consumed in delays; and, incidentally, to procure for the benefit of other lines of research, authentic and well characterized samples of raw and partly finished wool and the corresponding finished worsted goods.

C. History and Evolution of This Work

The study of wool structure and its possible modification by chemical treatment, as a means of extending the range of usefulness for domestic wools and mohairs, was initiated in 1948 under the Research and Marketing Act. Work was immediately begun on the preparation of various chemical derivatives of wool and on the study of their structure and properties. New techniques and methods of animal-fiber investigation were developed. At the same time, a comprehensive study of the structure and mechanical properties of wools of various genetic, geographic, and dietary origins was initiated; this is now showing satisfactory progress. A contract with a private textile research organization was made by the Bureau to cover a study of the effect of subjecting wool to moist air for various periods of time at different stages of processing upon its spinnability. This work is about half completed, following the schedule set up at the start of the work.

D. Funds--Annual Expenditures

Expenditures on this project were approximately as follows: Fiscal year 1950, \$56,000; 1949, \$105,000; and 1948, \$11,000.

E. Examples of Outstanding Accomplishments

The development of wool of improved felting quality. A chemical derivative of wool, produced by reaction with a commercially available chemical compound (beta propiolactone), has been made and found to have unusual felting properties. This derivative not only felts to a greater degree than does untreated wool, but it does so at a much faster rate. These laboratory results have been confirmed with commercial-scale felting equipment in informal cooperation with a felt manufacturer. The commercial interest in these results stems from the possibility of reducing considerably the relatively long time required to make commercial felts. The same consideration holds for the fulling of woolen fabrics, which is a partial felting action that requires long periods of treatment.

F. Some additional Work Needed

Fundamental research. Correlation of the character and arrangement of the structural elements in wool and mohair fibers with the physical and chemical properties of both the individual fibers and the finished fabrics woven from them is needed to point the way toward increased utilization for domestic wools and mohairs. This work should include the separation and characterization of the several components of the individual fiber, such as scales and spindle cells. The properties of the fiber are influenced by each component; so a clear picture of the composite will be dependent upon this work.

Development of wool fibers having built-in resistance to moths and micro-organisms. Wool having permanent resistance to attack by moths and micro-organisms may result from reaction with proper chemicals. These should be sought and means for producing the desired reaction worked out.

Development of wool fibers having improved resistance to shrinkage. At the present time there is considerable interest in shrink-proof wools resulting from the treatment of wool with chlorinating agents or synthetic resins. These products are not entirely satisfactory, due to reduced strength, loss of desirable "hand", or other changed properties. A chemical treatment that would reduce the tendency to shrink without adversely affecting other properties would materially benefit the competitive position of wool.

UTILIZATION OF WOOL GREASE AND OTHER WOOL BYPRODUCTS

(BAIC - RM:a-200 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

To develop new industrial uses for wool grease and other wool byproducts and to develop methods of refining and modification for specific uses. Current work concerns the separation of the grease into its components and examination of those components.

B. Currently Active Line Projects

RM:a-200-1 - Chemical investigation of the constituents of wool grease. To determine the chemical constitution and properties of the components of wool grease and to use this information for the development of methods for recovery and utilization of these components. While uses for crude wool grease and the purified wool wax (lanolin) have been discovered haphazardly over a long period, and while these uses are numerous and important, they do not consume to best advantage all the wool grease that can be recovered. Hence this study is designed to isolate, characterize, and utilize, as chemical intermediates, the individual chemical compounds of which wool grease is composed, as has been done with coal tar and petroleum.

RM:a-200-2 - Solvent fractionation of wool grease and investigation of the fractions. To develop suitable methods for treating wool grease to obtain products having more desirable characteristics and composition for certain end uses, with special emphasis on the separation of fractions having suitable viscosity for use in the preparation of scourable sheep-branding paints.

RM:a-200-3 - Chemical engineering investigations on the fractionation of wool grease. To determine on a pilot-plant scale the technical and economical feasibility of methods for recovering the components of wool grease separately.

C. History and Evolution of This Work

Each year about 150 million pounds of wool grease are removed from the raw wool consumed in this country. Because the market for the grease is limited and the cost of recovery is high, normally only a small fraction of this material is recovered and utilized; most of it has been discharged into streams as mill waste. Laws prohibiting stream pollution, however, are eliminating this disposal outlet, and are forcing processors to install relatively expensive recovery and storage facilities, the cost of which must be added to the cost of the scoured wool. Full utilization of recoverable grease could turn recovery operations into a source of profit and improve the competive position of wool. In view of this fact, work was begun on this project in 1948. As recommended by the Wool Advisory Committee, emphasis is being placed on fundamental research Essential analytical methods are being developed, as well as methods for isolating the components in the purest possible form for determination of their physical and chemical characteristics. Pilot-plant studies are being made on low-temperature solvent fractionation of the crude grease. Information gained in this work should contribute to successful commercial separation and industrial utilization of wool grease and its components.

D. Funds - Annual Expenditures

Expenditures for this project have been as follows: 1948, $28,700; 1949, $39,000; 1950, $39,000.

E. An Outstanding Accomplishment

Scourable branding paints. The Bureau has cooperated informally with the Production and Marketing Administration of the Department in producing for field testing a paint that can be used for identifying sheep by branding without introducing into the fleece substances like tar, pitch, or paint that are difficult to remove from the fiber. This branding paint is made from wool grease from which some of the harder waxes have been removed and is readily washed out of the fiber by ordinary scouring methods.

F. Some Additional Work Needed

Water-soluble constituents. Accompanying the grease on the fleece is a water-soluble mixture called suint. The total amount removed each year is about 250 million pounds, of which little is recovered. Suint contains potassium salts of various organic acids and also numerous nitrogen compounds, some of which have not been identified. These potentially valuable suint components should be subjected to fundamental study.

Acids of wool wax. Some of the organic acids of wool wax have properties not shown by ordinary fatty acids. They may be valuable for special purposes. There is also uncertainty about the nature of these acids. A comprehensive investigation of the character of the acids in all types of wool wax is needed.

Reactions of cholesterol. The usual processes by which cholesterol (A sterol component of wool wax) is converted to useful products, such as hormones and vitamins, are complicated and give small yields. For that reason, imported vegetable sapogenins are being substituted. Further fundamental work on the reactions of cholesterol would undoubtedly broaden its utilization.

DEVELOP IMPROVED METHODS OF CLEANING AND SCOURING GREASE WOOL TO YIELD IMPROVED FIBERS

(BAIC - RM:a-372 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

To maintain the inherent strength on elasticity on wool fibers and to simplify the recovery of wool grease by the development of improved methods for cleaning and scouring grease wool, so as to improve the competitive position of wool. Current work is directed toward the development of new scouring methods that do not injure wool.

B. Currently Active Line Projects

RM:a-372-1 - Study of the Soap and synthetic-detergent methods of scouring grease wool and the effect of such treatments on the wool fiber. The objectives are (1) improve the efficiency of scouring processes using soap-and-soda or detergent solutions, (2) learn how to prevent lowing the quality of the scoured wool through physical and chemical investigations of the scouring process, and (3) to develop improvements in scouring processes based upon this more complete knowledge.

C. History and Evolution of this Work

Research on scouring of wool was initiated 2½ years ago. The work is needed because most of the woolen mills in this country scour wool by the old procedure of scrubbing in a series of tubs containing soap and soda in water. The process is slow, the wool is subject to chemical damage by the alkaline solution; and--most serious--the waste causes stream pollution. Although methods have been devised for recovering grease from the waste, these methods are so expensive that, for the most part, the mills have dumped the wash water containing the grease directly into rivers or other bodies of water. The resulting pollution has been serious, and with the present trend toward enforcement of legislation prohibiting stream pollution, the mills are faced with the necessity of devising an economical combination of wool cleaning, waste clarification and byproduct recovery. Under present conditions in the textile industry, any additional costs incurred in the processing of wool will tend to weaken the position of wool in competition with other fibers.

D. Funds--Annual Expenditures

Expenditures on this project for the fiscal year 1950 were approximately $10,000, and for 1949, which was the first year of operation, they were approximately $20,000.

E. Examples of Outstanding Accomplishments

Development of suint-alcohol scouring process for grease wool. A method for continuous scouring of grease wool with simultaneous recovery of by-product grease has been worked out and demonstrated successfully on a laboratory scale. This process utilizes certain constituents of the impurities in wool, the suint salts, in place of soap for removal of the grease. The suint salts are perspiration residues and comprise up to 20 percent of the weight of the grease wool. Fundamental studies made by the Bureau have demonstrated that the suint salts can be made more effective in grease removal when small quantities of alcohol are present. Furthermore, the grease is readily recovered from the waste as a byproduct. The alcohol is then used over again in repeated cycles. As compared with the conventional soap-soda process, this method of scouring should prove to be more rapid, and the equipment should require less space, since a relatively small volume of washing solution is used. It is possible that soaps and soda can be eliminated from the scouring process, thus lessening the probability of alkali damage to the wool.

F. Some Additional Work Needed

Further work on the suint-alcohol scouring process remains to be done before it is ready for large-scale evaluation. Studies of such factors as rate of flow and temperature, as well as experiments with a wide variety of wools, should be made.

Effects of scouring treatment on properties of wool fibers. It is known that the action of strong alkalies is detrimental to the properties of wool fibers. The degree of injury to the fibers at alkali concentrations commonly used in soap-soda scouring should be studied, and comparisons should be made with fibers scoured by the suint-alcohol process. Wool fibers scoured with synthetic detergents and also by extraction with organic solvents should also be examined to complete the comparative data.

DEVELOPING AND EVALUATING FABRICS CONTAINING WOOL OF KNOWN SOURCE AND GENETIC ORIGIN
(BAI - No. RM-a-427 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

To (1) determine the fabrication, felting, and insulating properties of different grades and classes of wool from sheep, goats, and rabbits of known breeds; (2) evaluate by serviceability tests wool and other fibers used for clothing and household articles; (3) stabilize and broaden the market for wool by developing textiles containing wool fibers mixed with other natural and synthetic fibers. Since 1942 the quantity of wool produced in the United States has declined rapidly and in recent years less than 20 percent of the wool used in mills, or only half of the country's normal consumption, was of domestic origin. Studies under this project are designed to stimulate a larger production of good wool or, in the interim, to extend our present domestic supplies. Current work includes the testing, sorting, carding, and combing of wool from sheep of known origin, and finding what characteristics in wools are associated with the best product. Determination is sought of the serviceability of men's utility suitings made from coarse western wools not now used generally for clothing purposes, as well as that of fabrics made from mixtures of wool and synthetic and natural fibers. Recently, investigations were begun on the differences between Australasian and American wools of comparable grades to judge their importance and if necessary raise American wool standards to meet competition from imported wools.

B. Currently Active Line Projects

RM-a-427-1 - Comparative serviceability of wool and part-wool suitings. To determine, through serviceability studies, the usefulness of suitings made entirely of wool of different grades and the effect on the wearing qualities and consumer acceptability of the fabrics of replacing part of the wool with other fibers.

RM-a-427-2 - Effect of aging of wool at various stages of manufacture on the serviceability of the fabric. To discover the effect of aging, following the primary processes of manufacture, on the usefulness of the fabric to the consumer.

RM-a-427-3 - Physical properties of apparel wools from animals of known breeding in relation to fabrication, felting, and insulating uses. To determine the fabrication, felting, and insulating properties and the relative usefulness of different types of apparel wools from sheep of known breeding and to identify and describe breed lines and flocks of sheep in terms of the fabricating, felting, and insulating properties and the relative usefulness of their apparel wools.

RM-a-427-4 - Properties of blanket and rug wools of known breeding and history in relation to their use for fabrication, felting, and insulation. To determine the relative usefulness of wools suited for making blankets and rugs from sheep of recorded breeding and to identify and trace individuals, strains, and flocks of sheep with such properties, and the relative usefulness of their blanket and rug wools.

RM-a-427-5 - Properties of mohair of known breeding which contribute to its use in fabrication and insulation. To determine the physical properties of mohair with respect to fabrication insulating properties and the relative usefulness of different types of mohair from goats of known breeding and to identify individuals, strains, and herds of Angora goats with respect to these properties.

RM-a-427-6 - Studies of the properties of Angora rabbit wool of known origin and history with respect to its use in special fabrication and for its insulating properties. To determine the fabrication and insulating properties and the relative usefulness of commercial types of Angora rabbit wool from rabbits of known breeding and with different physical properties; to correlate these properties with the usefulness of the wool, and to identify individuals and strains of Angora rabbits with respect to the properties and usefulness of their wool.

C. History and Evolution of This Work

Faced with a rapid decline of demand for domestic wool, which has been decreased by 50 percent since the peak year of 1942, sheep growers asked for aid through Federal research in finding ways of extending the usefulness of wool and improvement of its quality. Upon recommendation of the RMA wool advisory committee, the present project was begun on July 1, 1948. Some preliminary findings were available from a short-term project conducted from December 1947 to July 1948 on the relation of genetic factors to the market value of wool. In cooperation with other bureaus of the Department, work has been conducted on determination of such qualities as elasticity, warmth, resiliency, absorbency, and insulating ability of various grades and types of wool and mixtures of wool and other fibers. Fabrication, felting, and other commercial usefulness of different types of apparel wool are being investigated, and studies are under way to find means of improving both quality and quantity of wool through breeding, feeding, and management. Equipment for measuring fleeces for clean wool fiber has been installed and is in use.

D. Funds--Annual Expenditures

Expenditures for this project including the preliminary work in the fiscal year 1948, have been as follows:

Fiscal Year 1948 - $ 900
Fiscal Year 1949 - 42,600
Fiscal Year 1950 - 51,600

E. Examples of Outstanding Accomplishments

Development of new and effective procedures for analyzing the usefulness of wools of individual animals, strains, and families of sheep. These analyses form a guide to the breeding of sheep that will produce fleeces of greatest value and commercial usefulness. They were made by study of 12,000 fleeces from sheep on experimental ranges.

Research has not reached the point of practical application in most instances under this comparatively new project. Promising results are being obtained, however, from studies of means of improving domestic Merino wool to meet standards of such wool from Australasia, wool carding experiments, investigations of properties and increased commercial use of Angora goat and Angora rabbit wool, and effects of aging wool at various stages of manufacture. Marked improvement of wool-bearing animals through selective breeding and nutritional feeding is expected.

F. Some Additional Work Needed

Improvement should be made in wool fabrics for freedom from objectionable wearing qualities such as harshness and skin irritation to the end of making wool fabrics more pleasing and attractive to the wearer. Such a program would involve the identification of the desirable and undesirable wools, and provide information on the sources of these various wools so as to eliminate production of the undesirable and to propagate abundantly the most desirable. This program should also include searches for improvement in the wearing qualities of wool fabrics by the modification of the wool fibers through the application of physical and chemical processes, and in the blending of wools of various properties with each other, or with other fibers.

Identification should be made of the felting properties of various wools to discover those wools most desirable for felting and their production source, and to develop methods of processing or blending various wools to enhance their usefulness for felting.

Measurements should be made of the various properties of wools that contribute to their desirability for insulation by physical determination of resiliency. Wools of recorded origin should be used so that variations in insulating properties may be traced to their source.

The potential usefulness of various wool fibers for clothing and household furnishings has never been fully examined. Similarly, the effect on serviceability and warmth properties, of substituting other fibers for wool for garment fabrics and bedding, needs investigation.

BROADENING THE USE OF MOHAIR FIBER
(PMA - No. RM-c-461 - Federal - RMA Funds)
Contract

A. Purpose and Nature of Current Work

To expand the market for mohair fiber (the fleece of the Angora goat). Currently, the work entails determination of what uses account for most of current demand for mohair, the outlook for these markets, and development of new mohair textiles which will help to broaden the demand and decrease the fluctuations in this demand. Specifically, the objectives are: To survey the current market for mohair and determine those parts of the market for textiles into which mohair might gain entry or increased use; to develop suitable new types of yarns, fabrics, and finished products to fit these probable potential markets, and to present these products and their technical and economic advantages to the trade for its consideration; and to evaluate the potential markets for the products and the changes needed in marketing methods to realize the potentials.

B. Currently Active Line Projects

Due to the specialized nature of this project and the method of conducting the work, there has been no need for separate line projects. The entire project is being carried out by contract with a private agency, financed jointly by the Department and the Texas Sheep and Goat Raisers' Association pursuant to a cooperative agreement.

C. History and Evolution of this Work

This project arose out of the problems raised by a disastrous drop in mohair prices shortly after World War II, and the subsequent request for assistance by the producers of mohair. Mohair fiber is a specialty fiber which has always fluctuated widely in demand. It is extremely durable and was the preferred fiber for automobile, bus, and train upholstery up until the last war. It was also preferred for furniture upholstery until recent years. Because of its luster and resilience, it also found a considerable market in blends with wools for tropical worsteds and for some types of overcoatings. However, style changes and competition from synthetics and cheap coarse wools hit all these markets simultaneously shortly after the war. Prices of Texas adult mohair dropped from 65 cents per pound in April 1947 to 38 cents in the spring of 1948 in spite of a drop in production of about 15 percent. The Texas Sheep and Goat Raisers' Association asked the Department for aid in improving the market, raised $10,000, and placed it on deposit with the Department to meet one-third of the cost of this project. A contract was made in June 1949 with a private firm which had the services of an experienced textile engineer to survey the market and develop new fabrics. Under this contract, work has proceeded on the development and sample production of new mohair textiles designed to supply markets revealed by a preliminary survey. The contract calls for completion of the work by June 1951.

D. Funds--Annual Expenditures

There was no money obligated in fiscal year 1950 under this project. The entire contract cost of $30,000 was obligated in 1949, of which $10,000 was from the Texas Sheep and Goat Raisers' Association, and $20,000 from Research and Marketing Act Funds.

E. Examples of Outstanding Accomplishments

The initial survey indicated that the proper blends of mohair and other fibers could probably break into a number of markets in which mohair was never very important, and that in these markets, mohair blends might fit into a medium price range between synthetics and the wools, not adequately covered by any fabrics at present. The contractor was able to design blends that appeared suitable for all these uses, and proceeded with the production of sample products made from these fabrics. Several fabrics already show so much promise that elements in the trade have taken an active interest. One is a corduroy, using an all-cotton warp and a pile of a 50-percent blend of mohair with rayon. The pile on this corduroy, unlike that on other corduroys, is resilient and does not stay flattened out. A manufacturer of this type of cloth is sufficiently impressed with its superiority that he has already undertaken further development work on his own. Another promising product is a child's sweater which promises to appeal to the higher-class trade because of better appearance than many others now on the market and because, unlike the better sweaters now available for children, it appears that it will be fully washable. The buyer of one of the larger New York department stores is actively interested in this item. Several other fabrics look almost as promising, although the work is still not sufficiently far along to present them to the trade. It appears probable that the trade will take up some of these mohair textiles and the way may be shown to the producers to develop more outlets on their own, when necessary.

F. Some Additional Work Needed

This is an exploratory project in part, and in part a demonstration to producers of the sort of action needed to maintain a market for a textile fiber under today's competitive donditions. Some of the newly developed products may have a long-time stable demand, but past history indicates that in today's textile market continued demand for a given fiber cannot be taken for granted. Continuous research development may well be needed to keep up with style and other changes in the competitive market for fibers. Much of this may best be done by the producers themselves. The end results of this project may reveal what further types of research Government agencies may need to undertake.

CROSS REFERENCES - Utilization

For additional information especially pertinent to subjects reported on in this chapter, see also:

BAI - RM:a-510, Chapter 1, processing and utilization of animal fats and byproducts.
BAIC - RRL-4-7, Chapter 1, utilization of fats and oils.
BDI - a-5-7, Chapter 2, phosphatase test for goat's milk.
BHNHE - b-3-6, Chapter 25, properties of fabrics as related to selection, care, and use.
BHNHE - b-3-7, Chapter 25, clothing and household textile articles.
BHNHE - RM:a-341, Chapter 25, family utilization of cothing and household textiles.

RESEARCH, SERVICE AND EDUCATIONAL ASSISTANCE FOR WOOL AND MOHAIR COOPERATIVES
(FCA - No. a-1-6 - Federal - Regular Funds)
Part 2

A. Purpose and Nature of Current Work

The Department is authorized by Public Law No. 450 of the 69th Congress to conduct research, service and educational work designed to benefit producers through their cooperative associations in the marketing of their wool and mohair. Current work is concerned with the development of more efficient marketing through collecting and disseminating information on problems relating to wool and mohair cooperatives. Among these problems are found those dealing with organization, policies, merchandising, costs, competition, membership relations, preparation for market, grading, handling, financing, processing, warehousing and sampling.

B-1. Currently Active Line Projects

a-1-6-10. Cooperative marketing of wool in the United States. To prepare for publication an educational bulletin on cooperative wool marketing.

a-1-6-11. Analysis of operations and financial condition of federated wool cooperatives. To stimulate interest in obtaining greater efficiency in cooperative wool marketing by publishing information on costs, margins, and financial condition of over 20 large scale wool marketing cooperatives. To demonstrate the value of cooperatives maintaining uniform accounting records and to show the results of cost reducing methods of wool marketing.

a-1-6-12. Auction marketing of wool by cooperatives. To collect and disseminate information on the feasibility, need, and procedures for auction wool selling by cooperatives.

a-1-6-13. Cooperative wool processing. To collect and disseminate information on the possibilities, needs, costs and procedures for processing of wool by cooperatives.

a-1-6-14. Improvements in preparation of wool for marketing through cooperatives. This work is supplementary to technical research, conducted mostly under RMA contracts with cooperatives and in cooperation with PMA, to facilitate the arrangements for the work and the dissemination of the results obtained.

C. History and Evolution of This Work

Recorded history of wool cooperatives dates back to the 1870's when the first local informal wool pools were organized. There was a gradual expansion of these pools and there are now well over 100 of these organizations in existence in the United States. The first large scale wool cooperative was organized in 1909. The period of 1918-22 after World War I, with its undesirable wool marketing conditions, led to the organization of over a dozen state and regional wool cooperatives.

The passage of the Agricultural Marketing Act of 1929 and the creation of the Federal Farm Board to establish producer-owned cooperatives caused the formation of 17 new large scale wool marketing cooperatives. At the request of the large scale wool cooperatives plans were formulated for federating these associations into the National Wool Marketing Corporation with headquarters at Boston, Mass. The National organization was established in 1929 to provide financing, sales and research service for State and regional wool marketing cooperatives. At the present time there are 27 large scale wool cooperatives in the United States in addition to local wool pools. These organizations market about one-fourth of the domestic shorn wool production.

A minor amount of work was done on cooperative wool marketing prior to the passage of the Cooperative Marketing Act of 1926. In 1929 USDA Technical Bulletin 124 covering a two-year study of wool marketing in Australia, New Zealand, South Africa, England and France was published.

Service and educational work dominated the activities of the project from 1929-1935 but with more time available for research, FCA Bulletin 33, "Cooperative Marketing of Fleece Wool" and Circular E-10, "Using Your Wool Co-op" were published; also an educational movie "Cooperative Wool - From Fleece to Fabric" was developed for showing by 1939. A study of western wool auctions was completed in 1941, (FCA Spec. Report 86). During the war a project designed to conserve jute and railroad car space through baling wools was undertaken and results of this work published (FCA Spec. Report No. 99 - 1942). Early in World War II the Army Air Corps assigned to the Department the responsibility of securing increased production of shearling pelts to make flying suits for aviators. This project was successfully carried out by setting up State committees to work with producers and by coordinating the work of the producer committees with manufacturers and the Army Air Corps at Wright Field, Dayton, Ohio. In 1946 an analyses was made of the Marketing of the 1944 Wyoming Wool Clip under the CCC wool purchase program (FCA Misc. Report No. 98 - 1946). Two cartoon type educational leaflets were printed (Misc. Report No. 103 - 1947) to encourage better wool production and better preparation of wool for market.

D. Funds - Annual Expenditures

Only one full time wool specialist has ever been employed for this project. Approximately 10 percent of the time of two economists and 25 percent of the time of a clerk-stenographer have, on the average, been devoted to work with wool and mohair. It is estimated that $7,500 per year covered these costs prior to World War II and $10,000 per year since that time. About one-fourth of these funds are spent for travel and per diem.

E. Examples of Outstanding Accomplishments

Gains in cooperative marketing of wool. During the past several years wool cooperatives have handled an average of about 25 percent of the nation's shorn wool production, compared to an average of approximately 5 percent handled prior to 1930. This project has been beneficial to wool growers through helping improve marketing conditions. Competition injected by the cooperatives has benefited members and non-members alike.

Assistance in the organization and integration of successful cooperatives. Assistance was given in the organization of 17 new large scale wool marketing cooperatives. Twenty-four (24) of the State and regional wool marketing cooperatives utilize the facilities and services of the National Wool Marketing Corporation as a joint sales agency. The organization plans and papers for the National Wool Marketing Corporation were drafted by the Department in consultation with leading wool producers.

F. Some Additional Work Needed

Continuation of currently active line projects. It is believed that a continuation of work along the lines discussed will assist producers through improving wool marketing methodology.

MARKETING METHODS AND PRACTICES FOR WOOL
(PMA - Federal - Marketing Farm Products)

A. Purpose and Nature of Current Work

To improve the marketing of wool and reduce costs by (1) development of a quick, reliable and scientific method of determining the shrinkage of grease wool; and (2) by development of a scourable sheep branding fluid which will remain legible and durable upon the sheep for a full wool-growing period of one year and which still will be easily removed in the regular wool scouring process. This would eliminate the problems involved in paint removal during processing and would enhance returns to growers.

B. Currently Active Phases of this Work

1. Improvements in sampling of greasy shorn and greasy pulled wool, in bales, bags and piles in preparation for determination of shrinkage.

a. Improvement of present core sampling tools and techniques for grease wool in bags.

b. Development of new tools and techniques for sampling grease wool in piles.

c. Development of convenient and accurate methods for testing entire bags of wool.

2. Development of improved laboratory techniques and procedures for shrinkage determination.

a. Development of improved blending and subsampling procedures for large samples, including development of pressure coring tubes for subsampling laboratory samples.

b. Development of methods for scouring and drying entire samples.

c. Development of a rescour technique, a procedure whereby the wool samples are scoured, dried, opened and scoured again prior to laboratory analysis, in order to arrive at greater accuracy and stability in shrinkage results.

3. Development of a practical and generally acceptable standard for clean wool.

a. Demonstration of failings and inadequacies of the present standard or definition for clean wool.

b. Demonstration of advantages of the proposed rescour definition for clean wool.

4. Testing the use of fractionated lanolin and lanolin-rosin mixtures as bases for scourable paints and development of additional workable colors. The present paint based upon raw lanolin hardens unduly in cold weather; hence, refinement and testing of other formulas are under way. Also, colors in addition to red and black are being tested.

C. History and Evolution of this Work.

Wool as shorn from the sheep is termed "grease wool" and contains large quantities of natural grease, dried perspiration, sand or soil and different kinds of vegetable matter. These extraneous substances must be removed from the wool before it can enter the manufacturing processes. It is estimated that the loss which occurs in cleansing domestic wool ranges as high as 78 percent and as low as 32 percent, and this loss is known in the trade as "shrinkage." The shrinkage of grease wool influences its value more than any other factor. An illustration of the importance of shrinkage as a price determining factor is seen when Fine Territory wool selling on the basis of $2 per scoured pound decreases in grease value 2 cents per pound for each 1 percent increase in shrinkage. A small error in estimating the shrinkage on a clip of wool, therefore, may cost the grower considerable money.

The development of methods for the sampling of large lots of wool and for testing these samples was begun in 1938. A hand-sampling method first was developed, but this was found to be partially subject to personal bias. Later, a mechanical core-boring method was developed and this has proven practicable and quite accurate. By 1946, the field sampling and laboratory testing procedures had progressed to the point where the core-boring method was made the basis for settling disputes between growers and appraisers who were evaluating wool for purchase by the Government under the CCC Wool Purchase Program. In the 1947 CCC Wool Purchase Program, the core-boring procedure was adopted as the sole method of appraisal for lots larger than 10 bags.

Many of the sampling and testing procedures developed by the Department have been accepted by wool laboratories throughout the United States and the world.

For identification on the range, wool growers must brand their sheep. In the past it has been customary to mark sheep with paint or tar. However, the use of such materials results in manufacturing difficulties and added processing charges and often in damage to the finished cloth. These extra costs are reflected back to growers in the form of reduced prices.

Work on scourable branding fluids began in 1942. Preliminary experiments were carried on in 1942 and 1943 and field trials began in 1944. Final field trials were made in 1948-49. The wools branded with scourable paint in the early summer of 1948 were shorn in early summer of 1949. Arrangements then were made for testing scourability in ordinary commercial mill operations. The mill tests were concluded in March, 1950, and proved the branding fluid to be completely scourable. However, while a successful scourable branding fluid has been developed, it is necessary to test suitability of new formulas to overcome difficulties involved in applying the original formula paint in cold weather.

D. Funds - Annual Expenditures

Since this work was initiated, the average annual expenditure has been approximately $11,000, with only minor fluctuations from year to year.

E. Examples of Outstanding Accomplishments

1. Establishment of accepted methods for sampling and testing domestic wool, including the development of workable tools. This is a comprehensive accomplishment covering a multitude of smaller details. The work has demonstrated that large clips can be represented accurately by sample bags, that these can be represented by sample cores, and that the final laboratory results are more reliable than any other method of wool shrinkage and value estimation available today. While the dollar value to growers of this development cannot be determined, it is probable that the core testing procedure has saved growers hundreds of thousands of dollars annually. Moreover, this scientific method of shrinkage determination makes it possible to evaluate each lot or clip correctly and equitably.

2. Development of the sodium hydroxide method for determination of vegetable matter in wool. A technique using a sodium hydroxide-sodium hypochlorite solution first was developed. Further experimentation indicated, however, that the sodium hydroxide method was more rapid and economical and equally accurate. This latter technique now has been adopted as the official method of the American Society for Testing Materials. It also is being used in England and Australia.

3. Development of a standard method for determination of ash in scoured wool. When CCC began purchasing wool on the basis of core test results for shrinkage, it became necessary to develop accurate techniques for determining ash in wool, since ash accounts for a very material proportion of the impurities. A method was developed which has been accepted in wool laboratories and also has been adopted as official by the ASTM.

4. Development of a scourable branding fluid. This not only enhances the competitive status of domestic as compared with foreign wools, but it also will result in material savings to wool growers. The mill which undertook the testing of the paint estimated savings of approximately 3 cents per clean pound to the firm if all of their wools had been branded with the scourable paints. On the basis of the present American production, this development apparently has a potential commercial value of several hundred thousand dollars annually.

F. Some Additional Work Needed

1. Improvements in ash testing are needed. The standard method suggested by the Department has been accepted by the American Society for Testing Materials. However, the technique still is awkward, long-drawn-out and unwieldy. An apparatus should be developed which will turn out ash tests far more quickly and with greater accuracy than is obtained at present.

2. There is need for research in moisture testing. The entire wool industry recognizes that its moisture testing methods involve a considerable element of uncertainty and arbitrary decision. Research work is needed to put moisture testing upon a completely satisfactory and scientific basis.

3. Development of a new and quick method for estimating clean wool content in wool. This field of endeavor, which aims at determining the percentage of clean wool on the basis of the nitrogen content, would represent a complete break with old and traditional methods of wool analyses. The final results would be obtained in one analytical step instead of the customary four. Promising results have been obtained so far; however, the method still needs further work for perfection.

4. Field testing of modifications made in the scourable branding paint formula and testing of new colors. The original formula paint is unsatisfactory when applied in cold weather. Improvements have been made, but field tests are necessary to check performance.

PREPARATION AND PROCESSING WOOL FOR MARKET
(PMA-FCA No. RM-c-93 and 252 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

The purpose of this research is to determine ways and means of increasing the net returns to domestic wool growers and to improve the competitive position of domestic as against foreign wools, through better preparation and processing of wools for market. Specifically, the present project seeks to determine (a) the economic advantages to growers of various improved methods of preparing and marketing wools, including grading, skirting and processing; (b) the most economical place--ranch, interior warehouse, or central market warehouse--to carry out the preparation work; (c) general market acceptability of preparation work done on ranches or in interior warehouses; (d) the advantages to growers of selling tags, offsorts and short wools in scoured rather than in the grease state; (e) the advantages of any other feasible means of marketing wool by growers, including partial processing, such as combing; (f) effects of tags on clip value; (g) effect of black wool fibers and jute contamination on wool value; (h) development of better packaging materials and methods.

The research work covered herein is carried on cooperatively by the Production and Marketing Administration, under authorization of project No. RM-c-93, and the Farm Credit Administration, under authorization of RM-c-252, in cooperation with various growers in nine states interested in improved wool marketing.

B. Currently Active Projects

RM-c-93 - Preparation of wool clips at ranches, concentration points and warehouses and processing of experimental lots. The investigations under this project cover feasibility of ranch grading and skirting, interior warehouse grading of clips, marketing tags and offsorts in scoured state, processing small lots from experimental clips, all to determine relative returns to growers from marketing prepared and unprepared wools. Determination of market acceptability of the preparation work done also is ascertained.

RM-c-252 - Field study on preparation of wool for marketing through cooperatives. The investigations under this project supplement those outlined above under Project No. 93. Whereas PMA works through State colleges with wool growers, the Farm Credit Administration works with growers through wool marketing cooperatives, and in this way increases the scope and broadens the nature of the research possible.

C. History and Evolution of This Work

Wool growers had long recognized the fact that domestic wools were poorly prepared and marketed in comparison with foreign wools. As long ago as 1914 an attempt was made in Wyoming to introduce the Australian system of wool preparation. However, resistance to change on the part of the wool trade and technical difficulties combined to make the experiments unsuccessful.

Traditionally, the wool grower has shorn his flock, quite often of mixed breeds and ages, and has thrown the fleeces indiscriminately into bags regardless of variations in fiber diameter, staple length and other physical characteristics; tags and offsorts generally are packed with the wool. This procedure may be likened to the process of putting different varieties and sizes of potatoes into the same bag, together with some dirt.

The economic consequences of this method of operation during the first step in wool marketing are that the buyer not only must estimate the amount of wool and the amount of foreign material in each bag, but also the approximate proportions of each quality and of offsorts. These estimates necessarily must be in the buyer's favor to insure against loss and to cover expensive preparation in a central market.

Unless there is an abnormal demand for wool, therefore, the grower pays a heavy penalty for careless preparation of his product for market. Moreover, domestic wools so prepared cannot meet the competition from well prepared and packaged foreign wools. The U. S. Tariff Commission has estimated a difference in value in favor of foreign wools amounting to 12 cents per scoured pound during the period 1924-35; in the period 1936-39 the spread was estimated to have been 11 cents per pound. This is due to the poorer preparation and the manner of marketing the domestic wools.

The present program was started in 1948. Under Project RM-b-WM-5, nine western states had initiated a research program to evaluate possibilities for improving wool marketing. PMA signed Memoranda of Understanding with each of these nine states, providing that the colleges will arrange for cooperation by growers and warehousemen, and PMA will supervise the preparation of clips, determine market acceptability of work done, and arrange for any processing agreed upon. BAE cooperates with the nine states by analyzing central market practices in handling wool.

The work in 1948 which involved cooperation with only three of the nine states, contemplated grading and skirting wool on ranches. After one year, however, it was found that skirting of the fleeces, i.e., removal of belly wool and offsorts, was an uncertain and complicated operation to undertake at the outset of the program. Skirting meant that the individual grower had many small lots of off wools to dispose of and it became evident that the discount on these wools might outweigh the premiums received for better preparation, unless ways and means were found to combine or pool the small lots. Consequently, the following year, 1949, skirting of fleeces was eliminated, the idea being that the primary step in better preparation of wool clips for market, namely fleece grading, should be the first to be tested for practicability, quality of work and costs. If the ranch grading proved successful from the growers' standpoint and if the results proved generally acceptable to the trade and industry, ranch or interior warehouse skirting again might be subject to investigation.

During the Spring of 1950, growers in several states were showing an increasing interest in combing a portion of their clips selected at random, in order, first, to obtain information regarding specific quality of the wools and, second, to determine relative returns from selling wool in the grease as against selling identical wools in processed form. At the same time, much interest also developed in a program of scouring and pooling the tags and offsorts from the prepared clips in order to determine the possibility of enhancing clip returns from this method of operation.

D. Funds - Annual Expenditures

Year	PMA	FCA	Total
1948	$10,800	$2,800	$13,600
1949	23,800	4,000	27,800
1950	22,700	9,700	32,400

E. Examples of Outstanding Accomplishments

1. The study has shown wool manufacturers that wool preparation on ranches, such as grading, can be accomplished so as to meet their requirements in processing operations.. This finding already is gradually overcoming decades of prejudice against any wool preparation work done outside the Boston area and outside commercial warehouses. The value to wool growers of having ranch-prepared wool accepted by manufacturers is about 1/2 cent per pound since it would cost 1 cent per pound to grade wool in a warehouse. If all the ranch wool in the United States were graded on the ranches this would mean an additional annual return to growers of several hundred thousand dollars.

2. The study has served to point out to wool growers the minimum facilities - space, light, bins, labor, etc. - necessary for efficient and proper ranch preparation of clips. Observations indicate that some growers already are rearranging shearing facilities to permit economical and acceptable preparation. The study further shows that with adequate facilities, ranch grading can be accomplished at a cost averaging approximately 1/2 cent per pound.

3. Results of the work to date show that the net savings to growers from effective ranch preparation of clips is contingent upon the returns obtained from offsorts. It has been found that these offsorts from several ranches must be pooled and sold as one lot in order to gain full advantage from the work done. Preliminary data also show that the offsorts probably should be scoured in order to bring maximum returns to growers.

4. Information obtained to date indicates that wool growers can gain materially from efficient packaging of their wool at time of shearing. Figures for 13 experimental clips in 1949 showed a difference in weight per bag of over 100 pounds, with essentially the same grades of wool involved. The difference in cost of bags, handling, weighing, coring, etc., in favor of the well packaged clip amounted to approximately 1 cent per grease pound.

F. Some Additional Work Needed

More competitive buying practices needed. So far most clips have been purchased individually, often without benefit of any competitive bidding. The buying may be done by local representatives of Eastern firms or the wool may be consigned to Boston for sale. Any deviation from this more or less non-competitive wool buying procedure always has met with strong opposition from some in the wool trade.

However, the growers have no specific information upon which to base any changes in selling methods. It would be of considerable economic importance to wool growers, therefore, to initiate a program of better preparation of their clips and experimental selling at certain interior concentration points, either on the basis of open auction or sealed bids. With better preparation of the domestic clips and with competitive buying, not only should the wool grower gain in net returns, but the market advantages now enjoyed by foreign wools would be lessened very materially.

Data needed on ways to market offsorts and short wools. In addition to development of improved preparation and selling methods for the main sorts and for the better qualities of individual clips, work should be undertaken on the problem of handling and marketing offsorts and short wools. With better preparation, such as grading, the grower is faced with the problem of how to dispose of small lots of offsorts without too much discount. Pooling and scouring these lots appears to be a solution, but specific factual data are necessary to initiate such a program on a broad scale.

DEVELOPMENT, PROMULGATION, AND DISTRIBUTION OF WOOL, WOOL TOP, MOHAIR AND MOHAIR TOP STANDARDS

(PMA - Marketing Farm Products - Federal)

A. Purpose and Nature of Current Work

This work is intended to develop and improve standards and grades for wool, wool top, mohair and mohair top, primarily on a visual basis. Such grades and standards aid growers in classifying and marketing their product; make available the official grades and standards used by dealers, manufacturers and producers; facilitate national and international trading and procurement of wool and mohair by defense agencies; and assist the Customs Bureau in tariff matters.

B. Currently Active Line Projects

1. Development of visual grease wool market grades. This work consists of development of approximately 1/2-pound samples representing the fineness, length and other characteristics demonstrating the six principal market classes of wool: Fine, 1/2 blood, 3/8 blood, 1/4 blood, low 1/4 blood, common and braid. These practical forms will reflect the range of fineness normally found in the respective commercial grades.

2. Development of market grades for mohair. This work consists of development of visual grades for use in classifying mohair. Seven grades for both Spring and Fall shorn mohair have been tentatively established. Following general acceptance of the prepared grades by the trade and by producers, official standards will be established.

3. Development of improved sampling and measurement methods for wool, wool top, mohair and mohair top. This work is necessary due to technological advancements in the textile fields. It will assist in developing quantitative specifications for important physical characteristics such as fineness, length, crimp, strength, elasticity, color and luster for grades of wool, mohair, and top. Special attention is given to more rapid measurement methods with reference to fineness, distribution, length and other physical characteristics important to the evaluation of the commodity.

4. Preparation and distribution of official wool, wool top and mohair standards. This work consists of the selection and preparation of samples for ready reference by the trade, manufacturers, growers, customs officials, commodity exchange, wool top exchange and others, representing the official grades of wool, wool top, and mohair, as promulgated by the Department of Agriculture.

C. History and Evolution of This Work

Existing visual wool and wool top grades based on fineness of fiber were promulgated in 1926; and in 1939 grades of wool top with quantitative specifications were established for grades 80s to 50s inclusive. Wool top grades 48s to 36s are visual; quantitative specifications for these and also for mohair and mohair top are lacking. Proposed visual market grades for wool are being promulgated. Visual market grades for grease mohair have been promulgated. Technological advancement in wool manufacturing meanwhile have brought about a real need for continued effort to develop quantitative specifications and improve methods of sampling and testing. The present standard specifications for wool top grades 80s, 70s, 64s, 62s, 60s, 58s, 56s, and 50s need revision due to changing practices in processing and methods of preparing wools and changes in spinning machinery. Wool top grades 48s to 36s are visual and need to be defined quantitatively.

D. Funds - Annual Expenditures

Approximately $10,000 was available annually for this activity from its inception until 1942. In 1942 the amount was increased to $27,000 and since then has averaged about this amount each year. The amount available for 1950 was $34,000.

E. Examples of Outstanding Accomplishments

The market grades for wool and mohair being developed are the basis for a service of inestimable aid to growers in guiding them toward (1) better classification for improved preparation of their wool clips for market and (2) their better estimation of the value of the clips, thus placing them on a more nearly comparable competitive level with wool buyers.

The accomplishments in the preparation and distribution of practical forms for official wool, wool top, and proposed mohair standards are of a continuous nature, orders being filled as requested.

A film strip which consists of 5 known mean diameter and variability expressions for 13 grades of wool from 80s to 36s has been developed. The expressions have been photographed onto a 35-mm. film strip which contains a total of 85 examples. It was developed for use and distribution to the trade, testing laboratories, agricultural experiment stations, and those doing research, testing and grading work. It permits rapid estimating of fineness and variability in wool or wool top. This film strip not only will permit more speed in fineness measurements, but it will mean very material dollar savings to those who employ it.

A significant proportion of the sampling and measuring work performed under this project is basic to and supplements the development of quantitative specifications under RMA Project No. 359.

Development and refinement of wedge scales used in fiber measurement work gave impetus to wool grade study all over the world. The origin by Lauth of Germany and introduction by Von Bergen into this country of the wedge method of fiber measurement freed investigators from the laborious task of direct microscopic measurement of the fibers. The early wedge, of cardboard or paper, was limited in scope unless printed on a long, unwieldy strip. The Wool Division developed an improved scale by increasing its length to make it applicable to all the grades from fine to coarse, and yet shortening the strip by telescoping the wedge.

A further improvement on the wedge was later made by the Wool Division by imprinting the class intervals on the strip, thus speeding the determination of the frequency distribution of the fibers.

At the request of leaders in wool fiber research for a standard scale, the Department made its wedge scales available to the industry for some years, later encouraging private industry to undertake the printing and distribution of the scales which are now used by almost all laboratories in the industry in their routine testing.

A special micrometer was developed for calibrating microprojectors for wool fiber measurement by the Wool Division. Although the Department had promulgated an official method for wool fiber measurement for purposes of the wool top standards, the calibration of the instruments by different laboratories has been regarded as a possible source of variation in measurement of similar stock. In order to make uniform calibration possible, the Wool Division developed a special stage micrometer by which the desired magnification could be obtained readily and uniformly in all laboratories. This stage micrometer is in production by one of the large optical companies and distribution is now being started. Orders have been placed by many of the leading mills and other testing laboratories, and the instrument will soon be in general use within the industry. It should prove a valuable aid in fiber fineness determination by making possible the uniform calibration of the microprojectors. This will aid industry and others concerned in purchasing and marketing wool and top where the Wool Top Exchange and defense agency specifications must be met for delivering a certain quality of product.

In cooperation with the American Society for Testing Materials and other agencies, an interlaboratory study was conducted on a special top to be used by the Department of the Army for one of its service fabrics.

In enlisting the aid of the American Society for Testing Materials in connection with this sample, the Army wished to obtain (1) the fineness composition of the top and (2) a procedure or method for testing the top for fineness determination. Since the Wool Standards Section of the Department of Agriculture has conducted much of its own research in cooperation with the membership of the ASTM, and since a member of the Standards Laboratory is chairman of the ASTM Wool Fineness Committee, the Wool Division is looked to for leadership on wool fineness work. Hence, the Wool Section of ASTM was asked to supervise the study. Preliminary tests first were made by the Wool Standards Laboratory to obtain an approximation of the fineness value. Next, procedural instructions were drawn up and sections of the sample prepared and distributed to 23 cooperating industrial, Federal, and State agricultural experiment station laboratories.

Results of the test were summarized and the specifications for fineness distribution and method of test were developed and recommended to the Army Quartermaster Corps. This resulted in wool top specifications for t the defense agencies' new uniform material.

F. Some Additional Work Needed

The Wool Advisory Committee has emphasized the urgent need for expansion of the work in the development of wool, wool top, mohair and mohair top standards. Work needed covers (1) re-evaluation and revision of the now existing standards and specifications for wool top grades 80s, 70s, 64s, 62s, 60s, 58s, 56s and 50s; (2) development of quantitative specifications for wool top standards, grades 48s, 46s, 44s, 40s and 36s; (3) development of mohair top standards.

IMPROVED GRADES AND STANDARDS FOR WOOL AND MOHAIR
(PMA - RM:c No. 359 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

This research is intended to develop quantitative specifications covering those physical characteristics of wool and mohair of the different types and grades which determine the value of the product, in order to permit more exact definition of quality, develop accurate and speedy methods of test, and in this way make it possible for the producer to obtain the full value of his product.

B. Currently Active Line Projects

1. Development of quantitative specifications for fineness and length for standard grades of grease wool matchings. This work is to determine the quantitative limits for fineness and length for 12 grades of grease wool matchings and the development of sampling techniques and methods of test.

2. Development of quantitative specifications and tolerances for standard grades of mohair. This work is for the purpose of developing accurate quantitative specifications for the different grades to replace the visual tentative grades.

C. History and Evolution of This Work

Only wool top standard grades 80s, 70s, 64s, 62s, 60s, 58s, 56s and 50s have quantitative specifications. At present, all grades of grease wool and mohair are expressed on a visual basis. In order to better define grease wool and mohair grades, work on expression of grades in terms of definite measurement of physical characteristics was initiated by the Production and Marketing Administration in July 1948. This work is in line with suggestions made by the Wool Advisory Committee, to better define the various grades of wool and mohair.

D. Funds - Annual Expenditures

Federal funds were expended on this project in the following amounts: 1949, $9,300; 1950, $12,300.

E. Examples of Outstanding Accomplishments

To date 18 lots of commercially graded wools processed from grease wool to top and samples from intermediate stages of processing have been tested to study the physical properties and characteristics upon which wool grades are based. Sampling techniques are being developed from these investigations which will speed up testing. New measurement methods to facilitate more rapid determinations of fineness and length are also being developed. These developments and accomplishments are coordinated with the sampling and measuring methods and techniques developed in work under the Marketing Farm Products program. The knowledge gained from these experiments will guide the development and establishment of quantitative measurement and specifications for new standards for grades and types of raw and processed wool so urgently needed for more satisfactory appraisal and marketing purposes.

Staple length measurement results have been determined on 296 samples of commercially graded wools, representing 2,683,000 pounds of grease wool. The current summarization of these results will be used to formulate length specifications for the various grades of wool. The application of these length requirements will better define the nomenclature used to express the length of grease wool. This will enable the producer to have a more complete knowledge of the value of his product as a basis for more sound marketing practices.

F. Some Additional Work Needed

Additional work needed covers the following:

1. Development of type specifications for domestic wools.
2. Development of standards for pulled wool and scoured wool.

PRICE, SUPPLY AND CONSUMPTION ANALYSIS FOR FARM PRODUCTS (WOOL)

(BAE - A-2-7 - Federal-Regular Funds; BAE-OES - RM:c-33 - Federal-State-RMA Funds)

(The discussion of line projects and expenditures on project RM:c-33 in this and other commodity chapters covers only work done by BAE. A general summary statement for this project, in Chapter 27, "Prices and Income" summarizes not only the research and expenditures of BAE but also shows expenditures of OES and lists OES line projects carried out through State and territorial experiment stations).

A. Purpose and Nature of Current Work

To (1) appraise the current and prospective economic position of wool and related fibers, and (2) make the results available through regular publications and on special request; (3) determine the Nation's future peace and wartime requirements for apparel wool; and (4) determine and measure factors affecting prices, consumption and utilization of domestic and foreign wools in the United States.

B. Currently Active Line Projects

A-2-7-11 - Price, supply and consumption analysis for wool and related fibers. To appraise the current and prospective economic position of wool and related fibers; to carry on the statistical and analytical work necessary thereto, to make the results available through regular publications and on special request to farmers, Government agencies and the general public. The Wool Situation is prepared and issued under this line project.

RM:c-33.6 - Consumption requirements and analysis of price, supply and consumption of apparel wool. To determine the Nation's future peace and wartime requirements for apparel wool; to determine and measure factors affecting the price, production, consumption and utilization of domestic and foreign apparel wools.

C. History and Evolution of This Work

(See this project in Chapter 27, "Prices and Income.") The RMA line project on wool was recommended by the Wool Advisory Committee.

D. Funds--Annual Expenditures

Expenditures from regular funds during the 1950 fiscal year amounted to $5,200; expenditures from RMA funds were approximately $8,400.

E. Examples of Outstanding Accomplishments

Regular Funds

An apparel wool survey is now being conducted for the National Security Resources Board to meet their requirements for basic information on this commodity in connection with their resources mobilization planning program.

RMA Funds

A report, "Domestic Wool Requirements and Sources of Supply," has been published jointly with the Livestock Branch of the Production and Marketing Administration. This report presents an analysis of the sheep and wool industry in the United States, civilian and military wool needs in relation to supplies of domestic wools, the relative advantages of imported and domestic wools, long-time trends in sheep and wool production, and the place of sheep in the agricultural economy of the United States. A second report entitled "Apparel Wool Prices," is now being processed for publication. This analysis indicates that a large part of the variation in the world price of apparel wool has been associated with world demand, as measured by an index of national income for the chief consuming countries, and with total world production of apparel wool. In the United States, consumer expenditures for clothing, including wool, vary with consumer purchasing power, but only a small part of the year-to-year variation in the mill consumption of apparel wool is associated with the level of income or with the prices of wool and woolen goods. This study also includes materials on the nature and uses of apparel wool, the nature of the demand for wool, the geographic distribution of world production, marketing practices in the chief producing countries, and the relationship between prices, domestic and foreign markets. In conjunction with this project, a statistical report, "Wool Statistics, Including Mohair and Other Animal Fibers" was completed and published in 1949. It includes data on production, prices, consumption, stocks, exports and imports of wool, mohair and other animal fibers. The work on wool under the RMA commodity project was terminated as of July 1, 1950.

F. Some Additional Work Needed

The outlook work on wool should be expanded to cover more thoroughly the competitive effects of other vegetable and animal fibers, synthetic fibers and silk, and analysis of the demand for wool needs to be further analyzed in terms of the demand for end products containing wool by industrial users and household consumers.

CONSUMER PREFERENCE RESEARCH (WOOL)

(BAE-BHNHE-OES-RM-c-31-Federal-State-RMA Funds)

(Related consumer preference research by BAE on other commodities is discussed in other commodity chapters. Consumer preference research conducted by BHNHE and OES, as well as line projects of BAE involving more than one commodity, are discussed in the general statement on consumer preference research in Chapter 26, "Economics of Marketing").

A. Purpose and Nature of Current Work

To find out (1) consumers' attitudes toward various articles made of wool, together with (2) the reasons for consumers' likes and dislikes, and their buying habits, as a guide to processing and marketing agencies. By helping these agencies to discover whether certain changes in the type of wool demanded are a reflection of current styles or of long-run trends, such research can help to stabilize the production, manufacture and merchandising of wool and wool products; and it can also help the consumer get the sort of goods he prefers. Current studies deal with men's wool clothing and with the use of wool in the construction of automobiles.

B. Currently Active Line Projects

RM:c-31.20 - Men's preferences among wool suits, coats and jackets To ascertain preferences for fabrics made of different grades of wool and the psychological motivations which help to determine choice in purchasing

RM:c-31.23 - Fabric and fiber patterns of use and preferences among automobile manufacturers (For discussion see Chapter 10 on Cotton.)

C. History and Evolution of This Work

Original research was begun in 1948. The work has been highly endorsed by The Wool Bureau and the Clothing Manufacturers Association of the United States. It is an extension to wool and wool products of the research methods which proved so successful in earlier work on cotton.

D. Funds—Annual Expenditures

Consumer preference research on wool undertaken by BAE during the fiscal year 1950 cost $82,000 from RMA funds.

E. Examples of Outstanding Accomplishments

Providing such practical findings that The Wool Bureau immediately used them as the basis of an extensive educational campaign. In addition, the Clothing Manufacturers Association of the U. S. and the Regional Laboratories of the Department have used the information. The report of only one of these studies is off the press at this date; it was well received by the industry, trade associations, manufacturers, and those concerned with marketing wool products. As the outstanding spokesman of the wool industry, The Wool Bureau has urged that the type of research described here be amplified to cover different kinds of consumers (household, industrial, and institutional) and a wider variety of products.

F. Some Additional Work Needed

Expansion of research to cover wool in women's clothing and in selected household fabrics. It is believed that the techniques used in Line Project RM:c-31.20, cited above, should be used. In addition, the wool industry hopes that work of the sort embraced under the term "consumer preference" can be brought to include several classes of industrial consumers of wool and wool products.

CROSS REFERENCES - Marketing

For additional information especially pertinent to subjects reported on in this chapter, see also:

BAE - A-2-1, Chapter 38, monograph on production and price supporting programs on wool.
BAE - a-2-22, Chapter 1, marketing livestock in the North Central Region.
BAE, PMA, BAI, No. RM:b-27, Chapter 1, marketing livestock and meat.
BAE - RM:c-205 and a-2-16, Chapter 26, marketing practices.
BAI - i-4-2, Chapter 1, disease conditions found during meat inspection.
BAI - i-4-3, Chapter 1, zoological investigations relating to meat inspection.
BAI - Control of miscellaneous animal diseases and interstate inspection, Chapter 35.
BAI - Meat inspection, Chapter 35.
BEPQ - RM:a-42, Chapter 31, preventing insect damage to wool, mohair, etc.
CEA - Commodity Exchange Act, Chapter 35.
EXT - Educational work in marketing, Chapter 37, market lamb pools.
EXT - RM:c-95, Chapter 37, marketing education on sheep, lambs, and wool.
EXT - RM:c-211, Chapter 37, marketing education on livestock and wool.
FCA - a-1-6, Chapter 1, livestock cooperatives.
FCA - RM:c-83, Chapter 1, processing meat products in frozen food locker plants, etc.
OFAR - Chapter 23 (especially RM:c-2 and RM:c-544), foreign activities.
PMA - Administration of U. S. Warehouse Act, Chapter 35.
PMA - Federal meat grading, Chapter 1.
PMA - Freight rates for farm products, Chapter 19.
PMA - Grades and standards for livestock and meat, Chapter 34.
PMA - Market inspection of dairy and poultry products, Chapter 34, domestic rabbits.
PMA - Packers and Stockyards Act, Chapter 35.
PMA, FCA - RM:c-75, Chapter 36, improved market facilities, etc.
PMA, BAE - RM:c-133, Chapter 34, grading and inspection of wool.
PMA - RM:c-430, 431, 432, Chapter 36, marketing service programs.
Chapter 32 for reports on crop and livestock estimates.
Chapter 33 for commodity market news service.

General Comment

The research, service, and marketing educational activities covered herein are reported for the most part on the basis of "work projects," the level at which various U. S. Department of Agriculture agencies keep separate financial records and prepare separate annual progress reports. The statements for these work projects give pertinent information on the nature and purpose of the work being carried on, and on the currently active "line projects," which are subdivisions of activity under the broader work projects. They also cover the history and development of the work, the Federal funds (and in a few instances the State funds) expended, some of the accomplishments, and some of the additional work needed in the areas covered by the work project.

Much of the work reported in this and other chapters of the over-all report is conducted in close cooperation with State agencies. While Federal-State cooperation is indicated for all such projects, it has not been feasible to report in detail the extent and nature of such cooperation. Also, except in specific types of work, no effort has been made to indicate the contributions of cooperating State agencies from the standpoint of accomplishments even though in many instances such contributions have been very important.

It should also be pointed out that the material in the over-all report has been organized, as far as possible, for the convenience of members of the Congress, members of commodity and functional advisory committees under the Research and Marketing Act, and others who are especially interested in specific segments of research, service, or marketing educational work.

- - - - - - -

Abbreviations of Agency Names

The numbering system used throughout this report includes the initials of the operating agency of the Department conducting or supervising the work.

ARA	Agricultural Research Administration
BAI	Bureau of Animal Industry
BAIC	Bureau of Agricultural and Industrial Chemistry
BDI	Bureau of Dairy Industry
BEPQ	Bureau of Entomology and Plant Quarantine
BHNHE	Bureau of Human Nutrition and Home Economices
BPISAE	Bureau of Plant Industry, Soils, and Agricultural Engineering
OES	Office of Experiment Stations
BAE	Bureau of Agricultural Economics
CEA	Commodity Exchange Authority
EXT	Extension Service
FCA	Farm Credit Administration
FS	Forest Service
OFAR	Office of Foreign Agricultural Relations
OI	Office of Information
PMA	Production and Marketing Administration
SCS	Soil Conservation Service

Table of Contents

FOREWORD

DECIDUOUS FRUITS AND TREE NUTS

Page

A - Production

Apples and other pome fruits

BPISAE-b-1-1-Apple and pear production diseases and improvement..... 13-1

BEPQ-I-b-2-Apple, pear and quince insects........................... 13-8

BEPQ-I-b-1-Codling moth investigations.............................. 13-12

Peaches and other stone fruits

BPISAE-b-1-2-Peach and other stone fruit production, diseases and improvement.................................... 13-16

BPISAE-BEPQ-RM:b-23-Research on the virus diseases of stone fruits.. 13-21

BEPQ-I-b-3-Stone fruit insects (other than Oriental fruit moth)..... 13-24

BEPQ-I-b-4-Oriental fruit moth...................................... 13-28

BEPQ-I-b-7-Dried fruit insect....................................... 13-31

Grapes and small fruits.

BPISAE-b-1-3-Grape production, diseases and improvement............. 13-35

BEPQ-I-b-8-Grapes and other small fruit insects in the East......... 13-38

BPISAE-b-1-4-Small fruit production, diseases and improvement....... 13-42

BPISAE-RM:b-530-Strawberry virus diseases........................... 13-46

Edible tree nuts

BPISAE-b-3-5-Edible tree nut production, breeding and disease....... 13-48

BEPQ-I-b-6-Nut insects.. 13-54

General or miscellaneous

BPISAE-b-1-5-Fruit production and improvement for Great Plains...... 13-58

BPISAE-b-1-7-Quality evaluation of fruits........................... 13-61

BEPQ-I-b-5-Insects and virus diseases (fruits)...................... 13-63

BPISAE-b-11-1-Introduction and evaluation of fruit and vegetable crops.. 13-66

Cross References.. 13-71

B - Utilization

BAIC-RRL-3-11-Utilization investigations on fruits of the Western region.. 13-72

BAIC-RRL-4-3-Utilization investigations on fruits of Eastern Region.. 13-96

BAIC-RM:a-125-New and improved uses of deciduous fruits............. 13-102

BAIC-RM:a-182-Equipment for juice recovery from fruit wastes........ 13-106

BAIC-RM:a-505-Fundamental characteristics of fruit tannins.......... 13-108

BAIC-RM:a-519-Factors influencing texture in processed berries...... 13-110

BAIC-RM:a-520-Instruments to measure color and moisture of fruits, vegetables and nuts.................................. 13-112

Cross References.. 13-113

Table of Contents (contd.)

C - Marketing

Page

BAE-A-2-7-Price, supply and consumption analysis for fruits and tree nuts.......... 13-114
BAE-OES-BHNHE-RM:c-31-Consumer preference research on deciduous fruits.......... 13-116
BAE-RM:c-163-Measurement of costs and margins (deciduous fruits).... 13-118
BAE,BEPQ,BHNHE,BPISAE,PMA-RM:b-165-Regional marketing on fruits..... 13-120
BAE-PMA-RM:c-389-Survey of marketing fruits, fruit products and edible nuts.......... 13-122
BPISAE-b-8-1-Handling, transportation and storage of deciduous fruits.......... 13-125
BPISAE-b-8-4-Market diseases of fruits and vegetables.......... 13-129
BPISAE-RM:c-552-Ripening pears after shipping and storing.......... 13-134
BPISAE-RM:c-553-Handling and shipping peaches.......... 13-136
PMA-BPISAE-RM:c-275-Regional marketing research.......... 13-138
PMA-Regular funds-Improving marketing distribution of fruits and vegetables.......... 13-140
Cross References.......... 13-142

FOREWORD

This chapter in the report on USDA research, service, and marketing educational work consists principally of statements on research work with deciduous fruits and edible tree nuts, classified under the three broad divisions of production, utilization, and marketing. Under production are placed the reports dealing with cultural practices, breeding or improvement, disease and insect control--grouped within four divisions of kinds of fruits or nuts. Under utilization are reports concerned with fundamental studies, as well as those designed to develop new and expanded uses as human food, for industrial purposes, for livestock feed, and with development of new equipment. Under marketing are reports on handling, storage, and transportation in the preservation of quality; price, supply, and consumption analyses; consumer preferences; costs and margins; and regional marketing research. Although the over-all report deals chiefly with USDA activities, it does include some work by State Agricultural Experiment Stations (Chapter 39), State Extension Services (Chapter 37), and State Departments of Agriculture or Bureaus of Markets (Chapter 36).

Cross references are listed at the end of each of the production, utilization, and marketing divisions. They point out sources of other information in Part II directly concerned with deciduous fruits or edible tree nuts, or which is of possible value to those interested in these commodities. These references provide the basis for a more comprehensive picture of the Department's work with the commodities.

Part I of the over-all report highlights some of the most significant accomplishments of the Department in the fields of research, service, and marketing education.

APPLE AND PEAR PRODUCTION, DISEASES, AND IMPROVEMENT
(BPISAE b-1-1 - Federal - State - Regular Funds)

A. Purpose and Nature of Current Work

To (1) breed varieties of apples and pears that will be fully hardy and will be resistant to diseases, such as pear blight, and which will have high dessert quality and good commercial qualities under the different conditions of the United States; (2) devise methods and materials for the control of diseases affecting apples and pears superior to those in current use; (3) improve methods of soil management and fertilizer practices for different areas; (4) devise better methods of fruit thinning by the use of chemicals; (5) find the most useful hormone sprays to prevent fruit drop of important varieties which now causes the loss of several million bushels annually; and (6) evaluate understocks for apples and pears that will be hardy in northern regions and will be resistant to the diseases that affect these fruits.

B. Currently Active Line Projects

b-1-1-1 - Breeding apples for hardiness and quality. To originate new varieties of apples that are fully hardy in northern States and that have desirable fruit qualities for home use and for market.

b-1-1-2 - Breeding pears for disease resistance and quality. To originate pears of high quality and long-keeping in the western United States and to originate varieties resistant to fire blight and adapted to climatic conditions in central and southern States, having desirable eating and canning qualities.

b-1-1-3 - Evaluation of varietal strains of apples. To determine the best strains of the color sports of apples for use by growers in the United States.

b-1-1-4 - Soil management and fertilizer practices. To determine the response of apple trees to orchard soil management and to fertilizer practices, and to devise improved methods.

b-1-1-5 - Nutrition of apple trees and symptoms of nutrient deficiencies.
To study the response of apple trees to the different elements, such as nitrogen, phosphorus, potash, magnesium, zinc, calcium, etc., and to note the symptoms of the deficiencies of these elements for use in correcting conditions in orchards.

b-1-1-6 - To determine the causes of water core, internal cork, bitter pit, and other physiological diseases of apple and to devise means of controlling these troubles.

b-1-1-7 - Drought spot and other physiological disorders of pear. To devise means to control drought spot and other physiological disorders of pears.

b-1-1-8 - Prevention of spring frost damage by use of hormone sprays to delay blooming. To find some hormone or chemical that sprayed on apple and pear trees will delay blooming until after frost damage.

b-1-1-9 - Prevention of fruit drop by preharvest hormone sprays. To study the conditions under which the different preharvest hormone sprays can be used on apple and pear trees to prevent loss by the fruit dropping before picking and differential varietal response to such materials.

b-1-1-10 - Thinning by spraying to increase fruit size and quality, save labor, and control biennial bearing. To study the conditions under which the fruit may be thinned by spraying at blossom time so as to increase the size and quality, save labor, and produce annual crops of large-sized fruit.

b-1-1-11 - Methods of improving water penetration in pear orchards having adobe soil. To devise methods of improving the water penetration in irrigated regions where very heavy soils make the usual methods difficult to use.

b-1-1-12 - Relation of tree growth to yield of pears under irrigation. To determine the amount and time of the use of irrigation water to obtain the highest yields of the best quality pears in irrigated regions.

b-1-1-13 - Fertilizer practices to improve yield and quality in bearing pear orchards. To study fertilizer practices and devise better methods and fertilizers to use in pear orchards to increase yields and improve quality.

b-1-1-14 - Development of new fungicide materials. To assist in the development of new fungicide materials to control apple and pear diseases.

b-1-1-15 - Testing of new fungicides for the control of apple scab and bitter rot. To test new fungicides and methods for applying them to control apple scab and bitter rot.

b-1-1-16 - Testing of new fungicides for control of perennial canker rot and other rots in the Pacific Northwest. To test new fungicides and methods of applying them for the control of these diseases in Pacific Northwest.

b-1-1-17 - Lime-induced chlorosis and its control. To study the yellowing of foliage of apples and pears under conditions where lime has been applied or on alkaline soils and to devise methods for control of this trouble.

b-1-1-18 - Testing of new fungicides for the control of pear scab in the Pacific Coast States. To test the new fungicides for the control of pear scab in the Pacific Coast States.

b-1-1-19 - Effect of DDT applied to apples upon vigor and quality of fruit produced. To study the effect of DDT and other organic materials applied to apples upon tree vigor and the quality of the fruit produced by the tree.

b-1-1-20 - Diagnosis and control of measles of apples. To study the causes of the troubles of apple called measles and to devise methods for control.

b-1-1-21 - Evaluation of understocks of apple trees. To test the new understocks of apple trees appearing in foreign countries and in this country and to evaluate them considering their vigor, hardiness, and resistance to disease.

b-1-1-22 - Evaluation of understocks for pear trees. To study the new understocks introduced from foreign countries and introduced in this country for pear trees, particularly as to their effect on fruit quality and tree growth.

b-1-1-23 - Cause and prevention of root-rot diseases of orchard trees. To study the root-rot troubles of fruit trees in different sections of the country and determine their cause and best methods for control.

b-1-1-24 - Leaf and stem diseases of fruit trees in the nursery. To study leaf and stem diseases of fruit trees in nurseries and devise means for their effective control.

C. History and Evolution of This Work

Studies on apple and pear production were started very early in the development of the Agriculture Department and extensive studies were made during the early 1890's. Much of the early work was concerned with the control of diseases, particularly pear blight and nursery troubles. The best varieties for different sections were evaluated in extensive studies and surveys. Beginning about 1930, emphasis was placed on the development and testing of new fungicides. This has continued to the present time. Extensive studies of the effect of irrigation, both under humid and dry-land conditions, and on control of biennial bearing were also begun about 1930. Specific effects of different nutrients on tree growth and fruit development and quality, and studies on the color sports of apples were begun in the 30's. During the late 30's studies were begun on chemical thinning of fruit and on stop-drop sprays. Recently, studies of prevention of cracking of the Stayman Winesap variety and of giant sports of the different varieties, particularly for use in breeding larger-fruited sorts, has been emphasized.

D. Funds — Annual Expenditures

A rough estimate of the annual expenditures from about 1890 to 1900 would be $10,000 to $40,000. From 1900 to 1920, the annual expenditures ranged from about $30,000 to $100,000; from 1920 to 1929 from $100,000 to $130,000; from 1930 to the present it has ranged between $132,000 in 1930, $121,000 in 1935, $178,000 in 1940, $138,000 in 1945, and $130,210 in 1950.

E. Examples of Outstanding Accomplishments

Pear blight control. In early work it was discovered that pear blight was spread by bees carrying the bacteria from flower to flower and tree to tree at the time of blossoming. By demonstrating that if all the blighted parts of the tree were cut out and burned pear blight could be controlled, the great pear industry of the Pacific Coast was made possible, and the entire western pear industry stands as a monument to this work.

Pear pollination. In the 1890's, workers in the Department first demonstrated that pears required cross-pollination for proper set of fruit and that the conditions from year to year and in any given locality determined the extent of the self-fertility or self-sterility of different varieties. Later, other workers found the same to be true for apples, some plums, and sweet cherries. This knowledge of cross-pollination requirement, now universally used by orchardists, has resulted in greatly increased crop production.

Apple blotch and bitter rot control. During the period 1900-1910 workers in the Department first demonstrated that bordeaux mixture was an effective fungicide for the control of these two serious apple diseases. Control procedures developed during this period were standard orchard practices until 1944. In that year Department workers showed that bitter rot could be controlled by the organic fungicide 2,3-dichloro 1,4 naphthoquinone. During the period 1944 to 1948 Department workers also demonstrated that ferbam (ferric dimethyldithiocarbamate) was a satisfactory substitute for bordeaux mixture for the control of the apple blotch fungus. The use of these organic materials reduced the losses due to copper injury which so frequently was the aftermath of the extensive use of bordeaux mixture.

Pear scab control. Department workers during the period 1940-1950 demonstrated that ferbam would control the pear scab fungus in the Pacific Northwest and at the same time not produce a russet type of injury on the fruit. This discovery has resulted in an estimated increased production of 300,000 boxes of Anjou pears each year.

Fungicide testing methods. Department workers have devised a routine procedure for testing the fungicidal properties of new compounds which combines a laboratory technique with a study of the effect of environmental conditions upon the fungicidal properties of the new compounds. This combined laboratory-outdoor screening procedure is considered to yield much more reliable data on the possible effectiveness of new compounds than the strictly laboratory screening procedures carried on in many laboratories. More than 700 compounds have been evaluated under this procedure. Some publications are as follows:

Apple Varieties and Important Producing Sections of the United States, Farmers' Bulletin 1883.
Establishing and Managing Young Apple Orchards, Farmers' Bulletin 1897.
Harvest Sprays for the Control of Fruit Drop, Circular 685.
Pear Growing in the Pacific Coast States, Farmers' Bulletin 1739.

The Control of Apple Bitter Rot, U.S.D.A. Bulletin 93, 1906.
Apple Blotch and Its Control, U.S.D.A. Bulletin 534.
Fungicides in Relation to Scab and Fruit Russet of Pear in the Hood River Valley, Oregon, Phytopathology, 35, pp 714-722, 1945.
Ferric dimethyldithiocarbamate--A Satisfactory Material for the Control of the Apple Blotch Fungus. Plant Disease Reporter, 32, pp 135-137, 1948.
Spray Experiments with Organic Fungicides for the Control of Apple Bitter Rot. Plant Disease Reporter, 28, pp 1035-1037, 1944.
Fungicidal and Phytotoxic Properties of 506 Synthetic Organic Compounds, Plant Disease Reporter, Supplement 182, 1949.

Nitrogen requirements of apple and pear orchards. In the 1930's studies in the Department indicated the best times of application of nitrogen and that increased amounts would result in greatly increased production of most orchards.

Chemical thinning of fruit. Beginning in the 1930's, studies were initiated on the thinning of fruits by chemicals to eliminate the expense of hand thinning. Chemical thinning at blossoming time resulted in a repeat crop the following year whereas trees thinned by hand usually would not come back with a good crop the following year. In some areas the increase in yield has averaged as much as eight field boxes of fruit per tree per year. The method is now in use on thousands of acres of commercial trees.

Stop-drop sprays. The discovery in 1939 that certain hormone-like chemicals would prevent the harvest dropping of apples and pears has been of tremendous value to the industry. When applied before the maturing of the fruit they will stop the fruit from dropping and make it possible to sell the several million bushels of fruit formerly lost from this cause annually.

Giant sports are tetraploids. Recently it has been found that the giant sports of certain apples and pears are due to tetraploid tissue, having four sets of chromosomes in the cells instead of two sets. Six of these tetraploid varieties have been discovered that can be used in breeding much larger-fruited varieties. A special technique has been devised to propagate fully tetraploid sports from those that are partially tetraploid, so that still other varieties can be made available for use in breeding.

F. Some Additional Work Needed

Development of tetraploid apples and pears. Tetraploid apples and pears so far have been about twice the size and of approximately the same quality as normal ones. Because triploid apples (with three sets of chromosomes) are so outstanding in tree and fruit characters, the use of a tetraploid apple (four sets) in crossing with a diploid (two sets) to get new triploids would seem to be one of the best ways of improving apples. So far the Department has been a leader in this particular line, trying to furnish breeders with tetraploids for use in getting varieties adapted to their conditions. Many partly tetraploid apples have been obtained, but these need to be made into full tetraploids so that they can be used by breeders. An example of the possible use would be the crossing of a tetraploid Winesap with the regular Grimes to give an apple of the Stayman type which would not crack and which would keep much longer.

Nutritional status of American orchards. Several local surveys have been made of nutritional status of apple and pear orchards. This work has helped greatly in understanding the soil and fertilizer requirements for such areas. However, there is need for a national survey of the nutritional status of orchards, standardizing the nutrient status for highest crop production and comparing well managed orchards on different soil types in various localities with such standards. Such studies could result in greatly changed soil fertility and soil management practices, and in greatly increased and more economical yields.

Mulching fruit trees. It has been demonstrated that mulch not only conserves moisture, but may be an effective way of applying fertilizers to orchards. Very large crops of hay mulch can be grown on otherwise waste land and this hay mulch may be made very high in nitrogen by nitrogen applications to the hay-producing land. Such mulch may be the most effective way of applying fertilizers to orchards in humid regions, particularly to control nutrient deficiency disorders. The effect of this method of applying nitrogen on other nutrients, on fruit color, and on pest control remains to be fully considered.

Maintenance of high nitrogen in fruit orchards. The application of nitrogen at high rates to fruit trees, both in the form of inorganic fertilizers and in mulches, should be compared with methods of applying nitrogen (as urea etc.) in various types of sprays directly to the foliage of the trees to determine if new practices can be developed which are much cheaper and more effective in maintaining high nutrient levels in orchards.

Development of new fungicide materials and practices. Some of the new fungicides cause far less damage, or no damage at all, to the foliage of fruit trees. Many new fungicide materials are being developed and should be tested to see if fully effective and cheaper fungicides may not be found for control of our tree-fruit diseases. Some of the new fungicides can be applied as concentrates at a much less cost than has been the practice in past years, and continued development of such concentrates should be studied.

Quicker results in apple and pear breeding. At present it is often 10 to 15 years before apple and pear seedlings can be evaluated for their qualities. This has hindered the development of improved varieties very greatly. Research is needed on (1) shortening the period of bringing apples and pears into fruiting so that they can be evaluated in three to five years instead of 10 to 15 years and (2) on developing methods of testing small seedlings for resistance to such diseases as pear blight, pear leaf spot.

Homogenious red sports of varieties needed. Red sports at present are probably all chimeral in nature and therefore can revert back to the original variety. To obtain homogenious red sports that will remain true, adventitious shoots should be induced on each such variety to form the future reliable stocks for propagation by the nursery trade.

Breeding apples and pears for southern regions. The remarkable adaptation of some pears of very poor quality to southern United States and the fact that species of small-fruited apples are also native to this region indicates that with modern plant breeding methods, fully satisfactory varieties of these fruits can be bred for this region.

INVESTIGATIONS OF INSECTS AFFECTING APPLE, PEAR AND QUINCE
(BEPQ - No. I-b-2 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of the work carried on under this project is to accumulate as much information as possible on the biology and habits of the several hundred kinds of insects that have been recorded as feeding on apple, pear or quince, (other than codling moth, for which see I-b-1) and with this as a basis, to develop effective and economical measures for their control. Some of these insects cause serious losses somewhere every season. Most of them are usually of minor importance, but they may at any time suddenly increase to great numbers. Currently, among the problems being given special attention are the orchard mites and red-banded leaf roller, which have become unusually abundant and destructive since general orchard use of DDT.

B. Currently Active Line Projects

I-b-2-6 - Studies of the causes of increases in mite populations in apple orchards following the use of DDT. To determine, as completely as possible, the exact way in which the use of DDT in orchards results in increases in mite populations.

I-b-2-7 - Studies of methods of controlling mites on apple trees. To develop effective and practical means of controlling mites in conjunction with the DDT spray program for codling moth control.

I-b-2-8 - Control of apple maggot. To develop effective programs for the control of the apple maggot in apple orchards that will fit in with the codling moth spray schedule and not cause excessive residue at harvest time.

I-b-2-9 - Tests of new insecticides for pear psylla control. To obtain full information on the value of certain new insecticides for pear psylla control in the Pacific Northwest.

I-b-2-10 - Biology and control of the red-banded leaf roller. To obtain detailed information on the biology and seasonal history of the red-banded leaf roller in different localities, to determine the reason for its sudden increase in DDT-sprayed plots, and to develop a spray program for its control.

I-b-2-11 - Effect of DDT on natural enemies of orchard insects. To determine the toxicity of DDT and other new insecticides to the natural enemies of orchard insects, and to determine the practical effect of such toxicity when the new insecticides are used on a commercial basis.

I-b-2-12 - Studies of miscellaneous apple, pear and quince insects. To accumulate as much information as possible on the less important pests of apple, pear, and quince for its value when sudden outbreaks occur.

I-b-2-13 - Control of woolly apple aphid on roots of apple nursery stock. To develop effective and economical methods of controlling the woolly apple aphid on the roots of apple nursery stock.

C. History and Evolution of This Work

At no time in the history of the Department have studies of this group of insects been absent from the program. In the first report (1863) of the first entomologist employed by the newly-formed Department of Agriculture, information was included on a number of insects that were then causing damage to apple, pear or quince. In the eighties, the San Jose scale, which had been found in California the decade before, came in for a great deal of investigation. In the next decade or two the same insect was under the spotlight in a number of eastern states. From 1910 to 1926 much work was done on a wide variety of apple and pear insects including the apple maggot, apple-tree borers and many others. In the early twenties a sudden increase in the extent of damage by the San Jose scale in the Middle West and the failure of lime sulfur to control it necessitated a restudy of the problem and the development of more effective insecticides. From 1926 until 1943, most of the insect problems of apple and pear were largely neglected in favor of the critical codling moth and spray residue problems. However, late in this period funds were allocated for a study of the Comstock mealybug, which at that time was causing serious damage in widely scattered eastern orchards. About 1947, after DDT had come into wide use, the pressure for work on the codling moth slackened and attention was shifted to orchard mites and other pests which had suddenly become much more important. About the same time the invasion of western pear orchards by the pear psylla made it necessary to devote considerable time and effort to this problem.

D. Funds--Annual Expenditures

The expenditures for studies of insects affecting apple, pear and quince have fluctuated widely, depending on the relative urgency of the various problems. Expenditures in the early years were made from general funds appropriated for use on entomological work, or from general allotments for deciduous fruit insect investigations. Close estimates on expenditures in these years are therefore not available, but they probably ranged from a few hundred to perhaps $5,000 in certain years. From 1910 to 1921 the amounts spent annually ranged from about $3000 to $9000. From 1922 to 1926, when the San Jose scale was being restudied, the expenditures varied from about $12,000 to $21,000. From 1926 through 1946, because of concentration on the codling moth problem, less work was done on the other insects of apple and pear. The amounts spent during this period varied a great deal, from as low as one thousand dollars up to $16,000, the average being about $7,000. Since that time the work on mites and other apple and pear pests has been stepped up markedly, and the allotment for the fiscal year 1950 was about $58,000.

E. Examples of Outstanding Accomplishments

Knowledge of the biology of apple and pear insects is basis of control. From time to time studies have been made of the biology of many insects affecting this group of fruits, and the results have been recorded in numerous Department publications. The biological information in these bulletins is most useful whenever any of these pests become serious enough to require consideration, especially in planning a research program to develop adequate control measures.

Value of lead arsenate in apple maggot control established. Studies carried on in Connecticut from 1918 to 1922 established the fact that lead arsenate is an effective insecticide for maggot control. This material has since been standard, except for situations where spray residue problems prevent its full use.

Lubricating oil emulsions saved Middle West apple orchards from destruction by the San Jose scale. About 1920, the San Jose scale, which for years had been controlled by the use of lime sulfur, suddenly became exceedingly destructive in the Middle West and killed many hundreds of acres of apple trees outright. For some unknown reason lime sulfur suddenly became ineffective. The work of the Department in the Ozark region showed that very effective control could be obtained by spraying with 2 to 3 percent of an emulsified low grade lubricating oil. This method, promptly adopted by the growers throughout the area, proved to be the salvation of the orchard industry.

New materials found for the effective control of pear psylla. With the invasion of the Northwest by the pear psylla in the early and middle forties and the scarcity of nicotine, a former standard material, extensive studies were made of various new insecticides, both in the Northwest and the Hudson River Valley. Growers now have a choice among several insecticides including parathion, ground cube root with oil, and toxaphene as a result of these studies.

Effective control of orchard mites made possible by new insecticides. With the general use of DDT, orchard mites have suddenly become much more abundant and destructive. The need for better insecticides than those formerly available is being met by intensive work. As a result of this work, several new materials have been found effective and are being used by growers in their spray program. Among the materials found thus far are several complex organic materials known to the trade as DMC, EPN, and Karamite. Parathion is also effective, but involves a serious hazard to the operator.

Parasites control Comstock mealybug. The Comstock mealybug, a pest of apple and some other fruits, suddenly became a pest of major importance in the middle thirties in a number of orchards scattered throughout the East, with the greatest damage in Virginia. The Bureau brought in several parasites of the pest from Japan that seemed to be controlling the mealybug in that country and liberated them in the infested orchards in the States. The mealybug outbreaks subsided within a very few years and no damage has now been done for some time.

Red-banded leaf roller controlled with TDE. The red-banded leaf roller is an insect that suddenly became important following the introduction of DDT, which is of comparatively little value in its control. Experimental work at points in the East and Middle West soon showed that TDE is extremely effective in controlling this pest. Growers promptly began using TDE and their losses to the red-banded leaf roller were cut to a very low point.

Parathion controls San Jose scale and other scale insects. Incidental to the work on the control of mites in apple orchards it has been found that parathion applied during the summer period is very effective in controlling the San Jose scale and certain other species of scale insects. Although this material is hazardous to handle, many growers who are using it for mite control are getting much incidental benefit in the control of scale insects. If the use of parathion turns out to be practical and safe, growers may be able to eliminate the dormant sprays of oil, which have to be put on during the period of the year when conditions are generally unfavorable for effective spraying.

F. Some Additional Work Needed

Continuous evaluation of insecticides needed. New insecticides are becoming available in increasing numbers. An essential part of the work on apple and pear insects should be the evaluation of such insecticides in order to determine the pests for which they are effective, the formulations and concentrations needed for various purposes, the effect on trees, foliage or fruit, and any disadvantages that may affect the practical use of such materials, including the effect on orchard workers, any possible hazard of residues to the consumer, and the effect of accumulations of the insecticides in orchard soils.

The effect of various insecticides on natural enemies of fruit insects should be studied more fully. The use of DDT was followed by serious outbreaks of mites and other pests, against which DDT is comparatively ineffective. Although the full explanation has not been developed, it is very evident that DDT has reduced or eliminated a number of natural enemies that would ordinarily keep these pests within bounds. A careful study of this entire field is needed, in order that insecticides may be used as far as possible in such a way that the effect on parasites and predators may be minimized, and preference given as far as possible to insecticides that have less of such effects. This research would fall under project I-n-5.

Control methods are needed for the woolly apple aphid in nursery stock. Many eastern nurserymen have to discard a third or more of their apple nursery stock because of the presence of galls produced by the root form of the woolly apple aphid. No practical method of dealing with this problem has been available until recently. There are indications that some of the new insecticides can be effectively used in the soil to prevent woolly apple aphid damage and a thorough investigation of this possibility is much needed.

CODLING MOTH INVESTIGATIONS
(BEPQ - No. I-b-1 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of current work is to develop better methods of controlling the codling moth, the most important apple insect pest in this country. In the absence of control measures the entire crop is often completely ruined. Before DDT, losses were estimated as more than 10 percent, or 13 to 25 million dollars annually, depending on crop values. Control with lead arsenate added at least an equal amount to the total cost of this pest to the grower. With the present use of DDT, losses and control costs are much lower. Currently, the objective is to develop even more effective and economical measures that (1) fit in with control programs for other insects and diseases, (2) leave no harmful residues on the fruit or in the soil, and (3) result in the least harm to natural enemies of various pests.

B. Currently Active Line Projects

I-b-1-1 - Preliminary laboratory testing of new materials or spray mixtures for codling moth control. To test in the laboratory possible new insecticides for the codling moth to determine whether they are worthy of more extensive experimentation.

I-b-1-2 - Laboratory field experiments in codling moth control. To obtain detailed information on the outdoor use of insecticides and spray mixtures applied for codling moth control, and to determine what new materials should be taken into large-scale field testing.

I-b-1-3 - Field testing of insecticides for codling moth control. To determine, under commercial orchard conditions, the value of various insecticides, spray mixtures, and spray programs for codling moth control.

I-b-1-4 - Laboratory and field tests of poison sprays and dusts against codling moth adults. To determine the effect on the moths of various insecticides applied for codling moth control, and to develop spray mixtures and programs that will kill as many of the moths as possible and thus reduce the number of worms that try to get into the fruit.

I-b-1-5 - Laboratory and field tests to determine the influence of particle size on toxicity and effectiveness of insecticides against codling moth larvae. To determine, for each insecticide that comes into use for codling moth control, the particle size that gives the highest degree of effectiveness.

I-b-1-6 - Laboratory studies on the use of the new insecticides with fungicides. To determine whether the newer insecticides can be used with fungicides, with which it may be necessary to combine them in practical orchard operations.

I-b-1-7 - Laboratory studies on poisoned baits for the newly hatched worms. To develop an effective bait for the newly hatched codling moth worm, in order that it may be killed before it tries to gnaw into the apple.

I-b-1-8 - Small-scale tests to determine effect of insecticides alone and with fungicides on fruit trees. To determine at an early stage in the investigations the probable effect of new insecticide materials, either alone or with common fungicides, on the foliage and fruit of the common orchard trees.

I-b-1-9 - Studies of methods of applying insecticides for codling moth control. To adapt the newer types of blowers, dusters, fog machines, both as ground equipment and in aircraft, to the control of the codling moth and other orchard insects.

I-b-1-10 - Studies of the development of differences in the ability of local orchard strains of codling moth larvae to enter fruit sprayed with lead arsenate or nicotine. To determine the prevalence of strains of codling moth larvae resistant to lead arsenate and nicotine bentonite, and how rapidly such strains can develop in heavily sprayed orchards.

I-b-1-11 - Studies of the development of differences in the ability of local orchard strains of codling moth larvae to enter fruit sprayed with DDT. To determine whether strains of codling moth larvae resistant to DDT may develop as a result of general and continuous use of this chemical.

C. History and Evolution of This Work

Work on the codling moth began soon after the Department was organized. The codling moth received brief mention in the 1870 Report of the Commissioner of Agriculture, and the 1887 Report included a 27-page summary of available information about this pest. The work on this insect was, however, more or less casual until 1900, when a Department worker spent the summer studying the problem in Idaho. Since that time the codling moth has been under continuous investigation. During the first decade lead arsenate came into the picture and the other arsenicals, such as Paris green and London purple, soon faded out. During the following decade and a half the field experiments dealt almost entirely with lead arsenate in various forms, in various schedules, and with different types of application. In addition, detailed life history studies were conducted in representative apple sections throughout the country. From 1926 to 1942 the work was dominated by two main factors--spray residue problems and increasing difficulty in controlling the worms because of increasing resistance to lead arsenate. Intensive efforts were made to develop more effective and less objectionable insecticides than lead arsenate. The possibilities of control methods other than spraying--banding to trap the worms, bait traps to catch the moths, and the use of parasites--were thoroughly explored. Since 1943 most of the work has been done with DDT and other new insecticides. The general adoption of DDT has resulted in outstanding control at a much lower cost, although the codling moth is still of potentially serious importance. Since resistance to DDT might develop suddenly at any time, research is being continued on a reduced scale on certain phases of the problem, at present mostly on new insecticides.

D. Funds--Annual Expenditures

Prior to 1900 the expenditures for codling moth investigations were nominal--at most a few hundred dollars a year. Expenditures for this purpose from 1900 through 1907 were between $500 and $2,000 per year.

From 1908 through 1925 the expenditures fluctuated greatly, and ranged between $7,000 and $25,000. With increasing difficulty with spray residue and failure of lead arsenate to give adequate control in certain areas, the expenditures steadily rose until they reached a maximum of about $108,000 in 1935, including about $60,000 of PWA funds. From 1936 to 1946 the expenditures ranged from about $65,000 to $85,000. With the general adoption of DDT and the consequent reduction of the codling moth to a minor status, for the present at least, the expenditures have since been steadily reduced. The 1950 allotment was about $19,000. The funds thus released have been devoted to other pressing problems, some of which have resulted from the use of DDT in orchards. Even at the highest point, expenditures for codling moth research have been less than .1% of the annual value of the crop, and less than 1% of the estimated losses caused by the insect annually.

E. Examples of Outstanding Accomplishments

Introduction of DDT into the orchard spray program vastly improved worm control. Because of the pioneer work of the Department with this insecticide, DDT virtually replaced lead arsenate within a period of five years. With its use the growers have reduced the codling moth from a pest of first importance to a very minor status, for the time being at least. In so doing, they have increased the proportion of fruit that was fit for the market, and have saved money on their spray costs.

Comprehensive studies on the biology of the codling moth form basis of spray programs. From 1909 to 1922 detailed biological studies of the codling moth were made in a large number of representative apple-growing sections of the country. These studies formed the basis of the successful spray practices developed by local and State agencies for their particular regions.

Lead arsenate permitted apple industry to survive. During the first 25 years of the century a great deal of work was done with lead arsenate. The studies included comparisons of paste and dry lead arsenate, the use of accessory materials, and the relative merits of different types of application. Treatments developed as a result of this work gave the apple industry in most areas good control of worms, and permitted it to survive. Unfortunately, however, lead arsenate was never fully effective in the arid western regions, and an even better insecticide had to be found.

The fact of resistance to lead arsenate on the part of the codling moth fully demonstrated. In work carried on in southern Indiana it became evident that lead arsenate had eliminated the worms that were the easiest to kill, leaving a much tougher race of worms to be controlled. Marked differences were found between orchards which differed in the history of lead arsenate usage. This factor, together with spray residue problems, gave added impetus to the efforts to develop more effective and less objectionable insecticides.

Chemically treated trap bands developed. Trap bands were used for codling moth control 100 years ago. They are placed around apple tree trunks to catch the mature worms when they leave the fruit, in order to reduce the next year's infestation. With the advent of spraying, growers stopped banding. However, with increasing difficulty in controlling worms, and in order to cut down the amount of spraying needed, this control method was revived. An improvement devised by Bureau workers in the late twenties, was the chemical treatment of corrugated paper bands, which became automatic in operation and reduced the amount of hand labor necessary. A 50 percent reduction in worm damage can be secured by the use of bands along with the scraping of the trees to eliminate other hiding places. Such bands were used successfully by many growers from 1930 to 1943, and can be used again if the worms should suddenly become resistant to the insecticides currently in use, and if labor costs should be reduced.

Other new insecticides for worm control developed. A number of new insecticides were developed for codling moth control during the period 1925 to 1943 that helped to meet the situation until DDT took over. Among these may be mentioned cryolite, which was fully equal to lead arsenate in the Northwest, and replaced it to a great extent there, and a tank-mix nicotine bentonite, which was more effective than lead arsenate in the Middle West, and largely replaced it in that area for several years. Phenothiazine also proved very effective in worm control under some conditions. Certain disadvantages prevented its general adoption, although small quantities are still used in a few eastern orchards. Following the discovery that phenothiazine had insecticidal qualities, it was also found to be of great value in the control of certain worms in livestock, and millions of pounds are now used annually for this purpose.

F. Some Additional Work Needed

The development and continuous evaluation of new insecticides is essential. Certain kinds of flies and mosquitoes have developed marked resistance to DDT within two or three years after its introduction. If this should occur with the codling moth, other insecticides should be available. Growers should never have all their eggs in one basket, as they did with lead arsenate for over 30 years. New insecticides should also be evaluated as they become available, in the hope that this work will lead to less expensive spray schedules, or materials that are even safer to use than DDT. There is growing concern over the DDT now accumulating in orchard soils, which may ultimately affect apple production or cover cropping practices.

Studies are needed on the possible development of resistance to DDT. As suggested in the preceding paragraph, it is quite possible that the codling moth will develop resistance to DDT although nothing of the kind has yet become evident. As soon as possible, studies should be made under laboratory conditions to determine whether the codling moth is likely to develop such a resistance in order that advance warning may be had if such is the case.

There is need of studies of methods of applying insecticides for codling moth control. Methods of applying insecticides in orchards are undergoing a rapid revolution, and the old-time hydraulic sprayer is being replaced by speed sprayers, mist blowers, and dusters. For some purposes spray materials are being put on by airplane or helicopter. Intensive studies of these newer types of equipment are urgently needed in order that more effective and economical equipment may be made available, as well as insecticide formulations for use in such equipment.

PEACH AND OTHER STONE FRUIT PRODUCTION, DISEASES, AND IMPROVEMENT
(BPISAE b-1-2 - Federal-State—Regular Funds)

A. Purpose and Nature of Current Work

To (1) originate through breeding, varieties of peaches, plums, apricots, and cherries of improved dessert and shipping quality, greater hardiness, and disease resistance, particularly adapted to the needs of modern conditions; (2) determine the best soil management and cover crop practices for peaches, and (3) test new fungicides and spray equipment for the control of peach brown rot and bacterial spot--the control of which is so difficult and costly.

B. Currently Active Line Project

b-1-2-1 - Breeding peaches for improved quality, hardiness, and disease resistance. To originate through breeding, peaches of better dessert and shipping quality, of greater hardiness and disease resistance for each region of the United States.

b-1-2-2 - Breeding of plum and apricot for improved quality, adaptation and disease resistance. To originate through breeding plums and apricots of better dessert and shipping qualities and of greater disease resistance, adapted to different regions of the United States.

b-1-2-3 - Investigations on rootstocks for peaches. To determine the best rootstocks for peaches in regions where nematodes and root rots are serious.

b-1-2-4 - Soil management and cover crop practices for peaches. To determine the best methods of soil management and cover crop practices for the production of peaches, particularly under humid conditions of eastern States.

b-1-2-5 - Response of stone fruits to mineral nutrients and determination of deficiency symptoms. By laboratory and field studies, to determine the symptoms of nutrient deficiency of stone fruits and to find methods of controlling such deficiencies.

b-1-2-6 - The effect of hormones in delaying blooming to escape spring frost. To find effective means of delaying blooming to escape frost, a major hazard at the present time in most peach regions.

b-1-2-7 - Sprays to increase production of peach trees by breaking dormancy. To determine whether there are any chemical sprays that may be used to break the dormancy of peach trees in southern regions when the peach trees do not get enough cold weather in winter to start normal spring growth.

b-1-2-8 - Methods of thinning to increase fruit size. To determine the cheapest and most effective methods of thinning peaches to maintain large size of fruit combined with high yields.

b-1-2-9 - Testing of fungicides and fertilizer practices for control of peach bacterial spot. To test new fungicides and to determine the relation of fertilizer practices in the control of bacterial spot which, by defoliating trees, weakens and predisposes them to winter injury.

b-1-2-10 - Testing of new fungicides for the control of peach brown rot and scab. To test the new fungicides to determine the best ones for the control of these important diseases.

b-1-2-11 - Evaluation of peach varieties for different methods of preservation. To test the newer varieties of peaches for canning and the frozen pack.

b-1-2-12 - Determination of the index for estimating potential fruit size of a peach variety. To determine whether a chart or sizing gage can be devised that will accurately indicate at thinning time the potential ripe fruit size of peaches, so that growers can use it in determining the amount of thinning required and the size of fruit for various purposes for which peaches are used, either for fresh market or for canning.

b-1-2-13 - Maintenance and evaluation of understocks for peach trees. To determine the suitability of a wide range of understocks for peach trees. Such understocks may prove to be useful in the control of certain virus diseases if the understock is immune to such diseases.

b-1-2-14 - Determination of the effect of DDT accumulations in the soil upon growth and production of deciduous fruit. To determine the effect of DDT accumulations in the soil upon growth and production of the different kinds and varieties of fruits using peaches as a test fruit.

b-1-2-15 - Peach rootstock toxicity in relation to replanting peach trees. To determine whether any treatment can be given the holes from which peach trees are pulled so that peach trees can be successfully replanted in the same place. At present in many areas it is hazardous to replant peach trees in these sites, at least for several years.

b-1-2-16 - Peach mosaic. To determine the host range and the resistance of different varieties to peach mosaic and to devise methods of eliminating injury from this disease in peach regions of the West.

b-1-2-17 - Western X-disease of peach. To determine the host range of this disease and the resistance of different varieties of various fruits to this trouble and to devise means of eliminating this as a serious threat to peaches in western States.

b-1-2-18 - Phony disease of peaches. To study the host range and conditions influencing infection and to devise more effective means of controlling this disease in the peach regions of southern States.

b-1-2-19 - Virus diseases of cherry, except "little cherry." To study the many virus diseases of cherry to determine their host relationships, to determine the resistance of different varieties to such diseases, and to devise methods of control of the losses from such diseases.

b-1-2-20 - Miscellaneous diseases suspected of being caused by virus. To study various obscure troubles which cause losses to peach, plum, cherry, and apricots, and to devise means of control.

b-1-2-21 - Discovery and control of vectors in virus diseases. To give technical assistance to workers in the Bureau of Entomology and Plant Quarantine and State entomologists in the search for the vectors of virus diseases and in finding means for the control of such vectors.

C. History and Evolution of the Work

Early studies were concerned chiefly with diseases of peaches; studies up to 1890 were on peach yellows and peach rosette. Between 1890 and 1900 peach leaf curl was studied. Between 1900 and 1910 satisfactory fungicides for the control of brown rot and scab of peach and leaf spot of cherry were developed. Beginning about 1920 a study was began of the phony disease of the peach in Georgia. Following this in the 1930's, a number of serious viruses of peaches, cherries, and apricots were studied in western United States. In recent years refinement of methods of applying sprays to peach trees for control of brown rot have been studied. During recent years emphasis has been placed on breeding peaches of high quality and greater firmness and hardiness particularly for southeastern and eastern States.

D. Funds -- Annual Expenditures

The annual expenditures from 1885 to 1900 ranged from about $5,000 to $30,000. Since 1900 the amount expended has gradually increased from about $30,000 to approximately $61,000 in 1940, $82,000 in 1945, and $131,330 for 1950.

E. Examples of Outstanding Accomplishments

Peach yellows control. By determining that peach yellows was a virus disease spread by a leafhopper and that it was necessary to rogue out trees affected with this disease, an eradication program was recommended and followed that made it possible to grow peaches commercially on an extensive scale in the Eastern States. Previously, at various times the whole industry in certain peach-growing areas had been wiped out by this disease.

Control of fungus diseases. Throughout the years, brown rot, peach leaf curl, and scab have been major troubles of peach growers but life history studies of these diseases and the origination of self-boiled lime-sulfur spray by Department workers made it possible to control them. Since 1945 it has been demonstrated that the control of blossom blight phase of brown rot greatly reduces the amount of fruit rot at harvest. This makes it possible to increase the proportion or amount of fruit that will hold up on the market.

Rootstocks for peaches. The serious losses from peach root nematodes resulted in the importation and planting of many orchards on Shalil and Yunnan seedlings. These stocks have proved resistant to a common species of the root-knot nematode but susceptible to another species often found in peach roots. It has recently been found that S-37 is a stock highly resistant to both forms of nematodes which cause such extensive losses to peaches in southern States. S-37 is so highly resistant that nematode trouble may no longer be a serious problem in peach growing.

New peach varieties originated proved valuable. Three peaches, Dixigem, Dixired, and Southland, originated by the Department, have given varieties much better adapted to southeastern States because of their greater firmness, higher quality, and, particularly in the case of the Southland, very high resistance to delayed dormancy in years when there is not cold enough to fully break the rest period. These new varieties are already being grown on thousands of acres. Nine clingstone varieties (Cortez, Coronado, Vivian, Andora, Fortuna, Shasta, Tudor, Carolyn, and Corona) adapted to canning have been introduced in California. These varieties supplement the older varieties for they mature at different seasons. Approximately 8,000 acres of them are being grown which constitutes one-third of all clingstones planted in recent years.

Control of peach mosaic. It has been demonstrated by Department workers that some varieties are highly resistant to this virus disease and these may be grown with no crop loss in areas where there is no chance of eliminating the disease. By determining that the peach mosaic is very rarely spread from apricot to peach, it has been possible in localities where both fruits are grown to control the disease in peaches by eliminating all mosaic in peach orchards as fast as it appears. By demonstrating that mild forms of the peach mosaic virus immunize against severe forms of the mosaic, it is possible now by using immunized nursery stock to grow susceptible varieties of peaches in peach-mosaic areas without loss of vigor.

Phony disease of peaches. Department workers have demonstrated that the phony disease of peach is a virus disease and that it is carried by certain species of leafhoppers. They also demonstrated that the disease is in the native plum around peach orchards in phony disease districts of southeastern States, and that eradication or removal of native plum reduces the rate of spread in established orchards and may prevent or materially reduce its development in new plantings.

F. Some Additional Work Needed

Breeding better peaches, plums, cherries, and apricots. Recent breeding work has very greatly improved the dessert and shipping qualities of peaches. It has also shown that it is possible to very greatly improve peaches in other ways, such as hardiness of bud and twig, and resistance to bacterial spot and brown rot. Similar research needs to be done with plums, cherries, and apricots. Actual origination of peach varieties with hardy buds and twigs and highly resistant to bacterial spot and brown rot remains to be accomplished.

Control of bacterial spot. Bacterial spot is still one of the most serious peach diseases of eastern States. Though control measures are known, they are very costly and in some seasons only fairly effective. Studies on the timing of the applications and the use of new sprays are needed for cheaper and more effective control.

Testing of new fungicides. Recently many new fungicides have been introduced which need to be tested for their value in the control of the more important diseases of peaches, cherries, plums, and apricots.

Breeding for nematode resistant stocks. Peach rootstocks which have seemed relatively nematode resistant at one time have not been resistant to all types of nematodes. Furthermore, other weaknesses appear. There is a need for positive and continuous search and controlled breeding to assure satisfactory peach stocks.

Replanting peaches. Because most of the best sites for peach orchards are now being used for peaches the problem of replanting peaches on old peach sites is becoming more and more serious. In many areas peach trees do not survive even the first year when planted on old orchard sites. Much more research is needed on this problem.

RESEARCH ON THE VIRUS DISEASES OF STONE FRUITS
(BPISAE and BEPQ - RM:b-23 - Federal-State—RMA Funds)

A. Purpose and Nature of Current Work

To control little cherry virus disease, particularly in the Northwest. Studies are being made on the symptoms of the disease on the various varieties on different stocks, on the relative rate of spread of the disease, on the insect vectors, on the host range, and the relation of this disease to other diseases of the various hosts. This disease has been studied extensively during the past three years because of its similarity to a little cherry virus trouble which killed out the commercial industry in one part of British Columbia.

All virus diseases of stone fruits appear to be carried by insects. The entomological work is to determine the insects that may transmit the virus responsible for little cherry and western X-diseases in the Northwest, to get information on the biology and habits of the insects responsible for transmission, and to develop measures that will augment other methods for the control of these diseases and the prevention of their spread.

B. Currently Active Line Projects

RM:b-23-1 - Survey of insects in and near stone fruit orchards in areas in western United States where little cherry, western X, albino cherry, and other stone fruit viruses occur. To provide information on the insects that may transmit little cherry, western X, albino cherry, and other lessor stone-fruit viruses in western United States, as a basis for insect transmission studies.

RM:b-23-2 - Transmission studies with insects suspected of spreading the little cherry virus disease. To determine the insects that transmit the little cherry virus disease, as a basis for the development of methods of controlling the insects to prevent spread of this disease.

RM:b-23-3 - Transmission studies with insects suspected of spreading western X-disease in the Northwest. To determine the insects that transmit western X-disease in the Pacific Northwest, as a basis for the development of methods of controlling the insects to limit or prevent natural spread of this disease.

RM:b-23-4 - Field studies to determine the time of year natural spread of little cherry disease occurs. A knowledge of the time of year natural spread occurs will help to reduce the number of insects on the list of those suspected of carrying little cherry disease, and may have an important bearing on tree removal practices for the control of this virus disease.

RM:b-23-5 - Field studies to determine the time of year natural spread of western X-disease occurs. A knowledge of the time of year natural spread occurs will help to reduce the number of insects on the list of those suspected of carrying western X-disease, and may have an important bearing on tree removal practices for the control of this virus disease.

RM:b-23-6 - Field tests of insecticides as a method of preventing or limiting natural spread of little cherry virus disease in western United States. To explore the possibilities in the use of new potent insecticides that are effective against the insects responsible for natural spread.

RM:b-23-7 - Field tests of insecticides as a method of preventing or limiting natural spread of western X virus disease in western United States. To explore the possibilities in the use of new potent insecticides that are effective against the leafhoppers or other insects responsible for natural spread.

RM;b-23-8 - The little cherry and X-disease virus complex. To develop methods of control of the little cherry and X-disease virus complex in stone fruits. To determine the symptoms early identification, rate of spread, host range, relation to other virus diseases of peach, cherry, plum, and apricot, value of immune stocks, possibility of immunizing against severe strains, value of chemotherapy.

C. History and Evolution of This Work

The little cherry disease, known for about 10 years in British Columbia, was found about four years ago in Washington State and other areas in the Northwest. It results in very small cherries of no commercial value. Extensive studies were begun in 1948 because of the damage it was doing and the extent of the commercial industry (crop valued at $20,000,000 annually) which it threatened. All the work is in cooperation with the State experiment stations of Washington, Utah, and Wisconsin and was begun in the late fall of 1947 or early in 1948. Several sports, or strains, of the disease have appeared. Some of these kill trees, others dwarf them. Studies to determine the insects responsible for natural spread of the virus responsible for little cherry, western X-disease, and related disorders and the development of control methods for them were undertaken in 1948 by the Bureau of Entomology and Plant Quarantine in cooperative studies in Washington, Oregon, and Utah.

D. Funds — Annual Expenditures

The annual allotments of the Bureau of Plant Industry, Soils, and Agricultural Engineering were about $34,000 for 1948 and $25,100 for 1949. The amount for 1950 was increased to approximately $45,400 to include funds for publication of a Handbook of Virus Diseases of Stone Fruits, needed as a reference manual by scientists, nurserymen, and growers. The Bureau of Entomology and Plant Quarantine expended approximately $15,000 in 1948, $16,000 in 1949, and $19,000 in 1950 on the insect transmission phases of the problem.

E. Examples of Outstanding Accomplishments

Identity of little cherry with western X-disease established by plant pathologists of the Department and cooperating State Agencies. It has already been demonstrated that "little cherry" is a symptom of the virus causing western X-disease of peach when cherry is grafted on mazzard root stock. When cherry is grafted on Mahaleb root stock, the same virus causes wilt and decline, and finally may cause death.

Handbook of Virus Diseases of Stone Fruit prepared by Department plant pathologists in cooperation with other research workers of United States and Canada. This monumental monographic illustrated book describes and illustrates over 40 virus diseases of stone fruits and is being published by the U. S. Department of Agriculture. It will be a reference manual of great value to research workers and regulatory officials throughout North America, and will undoubtedly stimulate efforts to solve the perplexing problems caused by these diseases.

Leafhopper carrier of the virus responsible for little cherry and western X-diseases found by entomologists of the Department and cooperating State agencies. This outstanding achievement, after only three years of entomological investigation, opens a new avenue of approach to the solution of the little cherry and western X-disease problems through control of the insect carriers. This discovery facilitates research into the host relationships of the virus with respect to herbaceous plants, and trees and shrubs not related to cherry or peach.

F. Some Additional Work Needed

Methods for controlling little cherry and western X-diseases. Although it has been found that a leafhopper spreads the virus causing little cherry and western X-diseases, methods of control have not yet been worked out. By controlling the leafhopper, by finding and eliminating diseased trees promptly, by finding immune or highly resistant cherries, or by topworking cherries to resistant stocks, some means of eliminating losses and preventing additional spread may be found. Many tests of control measures, including the laboratory and field evaluation of insecticides and cultural measures for leafhopper control, will be needed for years to come before growers can be assured of production of cherries and peaches in the Northwestern States without serious losses.

Search for additional insect carriers of little cherry, western X-disease, and other related virus diseases. Frequently more than one insect carries a plant virus disease. A knowledge of all of the carriers of little cherry and western X-disease will be necessary for a complete understanding of the control problems involved and their eventual solution. A preliminary finding that an aphid is responsible for the transmission of the virus strain causing cherry wilt or decline needs confirmation and further study.

INVESTIGATIONS OF INSECTS AFFECTING STONE FRUITS
(OTHER THAN ORIENTAL FRUIT MOTH)
(BEPQ - No. I-b-3 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to accumulate as much information as possible on the biology and habits of the numerous insects (other than the oriental fruit moth and those that spread virus diseases) that attack peach, cherry, plum and apricot. Some stone fruit insects cause serious losses every season, others only occasionally. With this information as a basis, effective and economical control measures can be developed. The problems being given special attention now include the (1) plum curculio, (2) peach tree borer, (3) tarnished plant bug, (4) stink bugs, (5) orchard mites, (6) San Jose scale, and (7) Forbes scale.

B. Currently Active Line Projects

I-b-3-1 - Studies of benzene hexachloride for control of the plum curculio on peach. To determine fully the value of benzene hexachloride as an insecticide for use in sprays to control the plum curculio on peach, and its effect on flavor; comparisons of the highly refined form (lindane) and the technical grade.

I-b-3-2 - Studies of new insecticides (other than benzene hexachloride) for control of the plum curculio on peach. To test and develop more effective insecticides for the control of plum curculio on peach.

I-b-3-3 - Studies of soil insecticide treatments for control of the plum curculio in peach orchards. To (1) determine the value of soil insecticide treatments against plum curculio larvae and pupae in the soil for use to control this insect as compared to the use of sprays and dusts against the adults on the trees, and (2) to find and develop effective materials for such use.

I-b-3-4 - Experiments with ethylene dichloride and propylene dichloride for peach tree borer control. To develop ethylene dichloride and propylene dichloride emulsions for effective, safe, and practical use to control the peach tree borer in trees of all ages in the different parts of the country where this insect occurs.

I-b-3-5 - Control of sucking bugs that cause deformed peaches. To determine the species of insects that cause deformed peaches and develop methods of preventing such injury.

I-b-3-6 - Control of pear thrips on prunes. To develop an effective method of controlling the pear thrips on prunes.

I-b-3-7 - Biology and control of the cherry leafminer. To obtain information on the habits and seasonal development of the cherry leafminer as a basis for development of control measures, and to develop an effective, practical method of control.

I-b-3-8 - Experiments with DDT and other new insecticides for the control of insects of the peach and other stone fruits in the Pacific Northwest. To determine the status and place of DDT and other promising new insecticides in the control of the more important insect pests of stone fruits in the arid sections of the Pacific Northwest.

I-b-3-9 - Studies of miscellaneous insects affecting stone fruits, east of the Rocky Mountains. To secure more complete information on the habits and seasonal development of miscellaneous insect pests of stone fruits of potential importance, and to develop improved control measures for them.

I-b-3-10 - Resistance of plum curculio to lead arsenate. To determine definitely whether the poor results with lead arsenate in recent years have been due to the development of resistance on the part of the plum curculio to this insecticide.

I-b-3-11 - Tests of new insecticides to prevent infestation by the peach tree borer. To develop a measure to prevent infestation by the peach tree borer of nursery stock and orchard trees.

C. History and Evolution of This Work

There has been no time in the history of entomological work in the Department, dating back to 1863, when some attention has not been given to studies of the biology, habits and control of some one or more of the long list of insects that attack stone fruits (peach, plum, cherry, etc.). Limited spray tests were made at least as early as 1887. A few of the many stone fruit pests are regularly of major importance in large areas. A number of others usually cause more or less damage and from time to time increase to more serious proportions. The plum curculio, peach tree borer and San Jose scale have been of major importance from the beginning but pear thrips, lecanium scale, cherry fruit flies, cherry leafminer, peach twig borer, lesser peach tree borer, green peach aphid, tarnished plant bug, stink bugs and others have been studied intensively at times. Many others have been given attention, usually incidental to other work. The serious losses caused by the plum curculio focused attention on this insect through the latter part of the 19th century until 1912, when improved control measures became available. In the late 1880's to the early 1900's, the San Jose scale shared attention with the plum curculio, and from 1911 to the present time, the peach tree borer has been a subject of intensive studies that were accelerated as the result of work with fumigants started in 1915. Failure of lead arsenate to give effective control of heavy infestations of the plum curculio and its tendency to cause injury to peach leaves and shoots led to resumption of work on this insect about 1915, that was accelerated during the 1920's and 1930's in an effort to find a substitute material that would not leave harmful residues on the harvested fruit. The availability of an increasing number of promising new organic insecticides in recent years has been the basis for reconsideration of the spray programs for all stone fruits. These investigations have resulted in rapid developments and improvements not yet fully appraised.

D. Funds--Annual Expenditures

With the early work on stone fruit insects sharing funds with work on pests of many other crops, estimates for early years are difficult to make. Annual expenditures prior to 1905 probably ranged from a few hundred dollars to $2,000 and from 1905 to 1913 from $2,000 to $4,000. Annual costs from 1913 through 1929 ranged from approximately $3,500 to $14,000. From 1930 to 1949 annual costs have ranged from approximately $7,500 to nearly $23,000, and the allotment for 1950 was about $24,000.

E. Examples of Outstanding Accomplishments

Lead arsenate control method developed for plum curculio. The lead arsenate method of control for plum curculio on stone fruits was developed through research and orchard demonstrations during the period 1905 to 1912. This was the first satisfactory method developed for the control of this serious pest on stone fruits. The method was adopted promptly by most growers and is still the basis for most stone fruit spraying programs where the curculio is a major problem.

Effective sprays developed to control San Jose scale. The rapid spread of the San Jose scale from the West alarmed growers of stone fruits in the eastern states in the late 1890's and early 1900's. This insect sucks the sap from the tree, first weakening it and then, as infestation increases, limbs are killed and finally the tree dies. Intensive studies led to development of a safe and effective lime sulfur formula that came into general use in the early 1900's. This treatment remained in use until the problem of scale resistance to the lime sulfur treatment prompted resumption of studies in 1922. These studies demonstrated the effectiveness of mineral oil emulsions in scale control and their safety when applied to stone fruit trees in the necessary concentrations. Recent studies have shown that it may be possible to do away with dormant oil sprays when parathion is included in the plum curculio spray program.

Life of peach trees prolonged materially by controlling the destructive peach tree borer. Work started in 1914 resulted in the development of the paradichlorobenzene treatment for controlling the peach tree borer. This is the insect that may girdle and kill a stone fruit tree in a year or two or weaken it to varying degrees according to the abundance of the insect. The most satisfactory method previously available was to dig the borers out by hand. This method often caused as much injury to the trees as the borers. Emulsions of ethylene dichloride were later found effective in borer control and less likely to injure young trees than paradichlorobenzene. These treatments and another, based on propylene dichloride, developed more recently, were promptly adopted by many growers and used with satisfying results. It has been estimated these treatments have lengthened the profitable life of peach orchards by as much as 50 percent. A net gain to the industry of about $3,000,000 annually resulted from these developments.

Pear thrips injury to prunes prevented by DDT. The most pronounced injury of the pear thrips results from the feeding of the adults before the blossoming period. Blossom stems become devitalized and the blossom buds are weakened and most of them fall off. This can now be almost completely prevented by following the recommended spray and dust DDT treatments developed cooperatively in Oregon. Growers are now using these treatments and are getting outstanding control.

New insecticides strengthen stone fruit spray programs. Intensive studies, many in cooperation with state experiment stations, have contributed a great deal to the development of parathion and benzene hexachloride for plum curculio control, DDT for control of sucking bugs that cause deformed peaches, benzene hexachloride and chlordane to control the cherry leafminer and DDT to control climbing cutworms and the shothole borer. These treatments have been widely accepted by growers and have given effective control.

F. Some Additional Work Needed

Evaluation and development of new insecticides needed for plum curculio control. Although several new insecticides have shown a great deal of promise for controlling the plum curculio and three of them, parathion, benzene hexachloride and chlordane, have had considerable commercial use, no one material is entirely satisfactory or has been proved enough better than the others to dominate recommended spray programs. Sometimes as many as three or four alternative programs are suggested, presenting a confusing situation for growers. All promising new materials should be evaluated as rapidly as possible with the objective of working out a simple, effective safe spray treatment for the curculio.

Treatment needed to prevent peach tree borer infestation. Present treatments for peach tree borer control are directed at killing off the young worms feeding in the tree. Prevention of infestation would be even more satisfactory, particularly for use in nurseries where even a little feeding injury may force the discard of affected trees. DDT and benzene hexachloride sprays show some promise in this direction and other new materials as yet untested may have value.

Parathion treatment for scale control needs perfection. Present indications of the value of parathion for controlling the San Jose and Forbes' scales during the growing season have come from studies of this material against other insects. More detailed studies are in order to determine the time and minimum number of applications, and minimum concentration needed for effective control of these scale insects on peach trees.

ORIENTAL FRUIT MOTH INVESTIGATIONS
(BEPQ - No. I-b-4 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to develop an improved, dependable, and practical means of controlling the oriental fruit moth, a major pest of the peach. Currently, the work involves (1) investigating its control by means of insecticides or (2) mass liberation of parasites or a combination of the two, (3) further studies of the number and time of spray applications in relation to harvest residues, degree of control and effect on biological control, and (4) the development of improved mass breeding methods for the more useful parasites.

B. Currently Active Line Projects

I-b-4-1 - Development of methods for mass rearing of fruit moth parasites. To further improve present methods of producing the parasite *Macrocentrus ancylivorus* in large numbers for the control of the oriental fruit moth; to develop methods for the rearing of large numbers of other effective fruit moth parasites.

I-b-4-2 - Colonization of oriental fruit moth parasites for establishment in new districts. To (1) introduce the various parasites of the oriental fruit moth into all important peach-producing areas where the parasites are not yet established, and (2) to determine the status of the parasites from time to time by means of recovery collections.

I-b-4-3 - Experiments with mass liberations of parasites for control of oriental fruit moth. To develop further the use of parasites for direct control of the oriental fruit moth by liberating large numbers of them in orchards.

I-b-4-4 - Investigations of bait traps for oriental fruit moth control. To develop the use of bait traps into a practical measure for control of the oriental fruit moth.

I-b-4-5 - Control of oriental fruit moth by means of insecticides. To develop an effective insecticide control program for the oriental fruit moth.

I-b-4-6 - Studies of influence of newer insecticides on abundance and effectiveness of oriental fruit moth parasites. To (1) determine the effect of the newer insecticides on the parasites of the oriental fruit moth, and (2) to work out control programs that interfere the least with parasite activity.

I-b-4-7 - Studies of combined programs for control of the oriental fruit moth. To determine the control of the oriental fruit moth that can be obtained by combining three methods--parasites, baits, and insecticides.

C. History and Evolution of This Work

Work on the oriental fruit moth was started shortly after its discovery in the United States in 1916 and continued through 1918. At that time attention was given to all phases of the problem--biology, habits, and control. Limited in distribution at first, this insect received little or no attention from 1918 to 1924. Its rapid spread throughout the East led to reestablishment of work in 1924 that has continued to the present time. The insect has since spread to nearly all peach-producing areas in the United States. Because of the lack of effective insecticides, emphasis was soon shifted to work with native and introduced natural enemies, bait traps and cultural control practices. Later emphasis was almost entirely on parasites as the more promising ones were colonized throughout the peach-producing areas where the insect was present. The advent of DDT and promising results in exploratory tests led to the present emphasis on control with insecticides.

D. Funds--Annual Expenditures

Expenditures in the early days of work on the oriental fruit moth were small and irregular, estimates being $1,000 for 1916 and $3,000 for 1917 fiscal years, none from 1918 to 1924, $500 for 1924 and $3000 for 1925. From 1926 to 1930 annual expenditures averaged about $11,000 per year, rose to about $90,000 in 1931 and dropped to approximately $26,000 in 1933. Since then annual expenditures have ranged from approximately $19,000 in 1934 to $38,000 in 1950.

E. Examples of Outstanding Accomplishments

A parasite, Macrocentrus ancylivorus, reduces fruit moth-damaged peaches by half. In studies of the natural enemies of the oriental fruit moth, the native parasite, M. ancylivorus, was soon found to reduce injury to a greater extent and more consistently than other native or introduced species. The lack of any effective and practical means of artificial control for many years focused attention on this parasite. As the result of Department work, methods were developed whereby it could be produced in large numbers. In cooperation with state agencies, this parasite has been introduced into most peach-producing areas in which it did not already occur. The work also led to commercial production of parasites for use by individual growers for immediate control. This parasite became established in a majority of the areas in which it was colonized and reduced the proportion of damaged peaches by about half. In the absence of control measures, fruit loss due to the oriental fruit moth frequently runs from 30 to 50 percent and in cases of severe infestation from 75 to 100 percent.

Newer insecticides found effective for oriental fruit moth control. Exploratory tests with DDT in 1944, in cooperation with state agencies, played an important part in the development of a DDT spray program that has come into wide commercial use. More recent studies have focused attention on control by sprays applied earlier in the season and on other insecticides, particularly parathion, less likely to cause harmful harvest spray residues.

Biological investigations aided further research. Studies conducted by the Bureau shortly after the oriental fruit moth was first discovered in 1916 have served as a basis for much of the work on this insect, both Federal and State, since that time.

F. Some Additional Work Needed

Improved spray program for oriental fruit moth control needs development. Too much DDT, especially near harvest time, may result in objectionable residues on the harvested fruit, too little DDT, especially if applications are poorly timed, may mean poor control. Increased efforts should be made to determine the time or times when DDT should be applied to be most effective. Other potent new organic insecticides that may not leave objectionable harvest residues, and various spray programs, should also be evaluated.

Parasite rearing methods need improvement. The utilization of the parasite *Macrocentrus ancylivorus* to control the oriental fruit moth was accelerated by development of a method of raising it in large numbers. For reasons not fully understood the number of parasites secured per unit of stock material drops markedly below expectations from time to time. This not only increases the cost of production but may result in an inadequate supply of parasites when they are needed most. In order that peach growers who continue to use parasites in preference to or in combination with insecticides for control may be assured of an adequate supply when needed, efforts to improve the methods of raising this parasite are well worth while. Growers obtain their supply of parasites from commercial producers who follow the methods developed by the Bureau for raising them.

Utilization of parasites in conjunction with insecticides needs investigation. To meet the need for even better control of the oriental fruit moth than has been secured by applications of DDT and other insecticides, studies are being made to determine the value of releasing large numbers of parasites in advance of the time the sprays are applied. Liberations after the sprays have been applied are undesirable, since most of the newer organic insecticides are very toxic to the parasites.

DRIED FRUIT INSECT INVESTIGATIONS
(BEPQ - No. I-b-7 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The objective of this work is to develop or improve upon methods of protecting dried fruits from infestation in the field, in the drying yards, and in storage houses, in order to reduce losses to the growers and processors and to provide the consumer with a high quality product at a reasonable price. Current work is concerned with (1) studies of the biology and habits of the numerous insects that attack dried fruits or fruits intended for drying to serve as a basis for control and (2) to test various methods of preventing insect-caused damage to such fruits either during production or after harvest.

B. Currently Active Line Projects

I-b-7-1 - Preliminary testing of new fumigants for control of dried fruit insects. To investigate any new fumigants that become available which appear to offer promise in the control of dried fruit insects, in order to develop cheaper, more effective, or less dangerous materials.

I-b-7-3 - Studies of the use of insecticides for protecting stored raisins from saw-toothed grain beetles. To determine whether infestation by the saw-toothed grain beetle in raisins stored in boxes can be reduced or eliminated by the use of insecticides, without contamination of the raisins with the chemicals.

I-b-7-4 - Determination of cold storage exposures lethal to dried fruit insects. To determine more completely the range of low temperature-exposure combinations that are fatal to the different stages of the various insect pests found in dried fruits, in order that full information may be available for those interested in the control of dried fruit insects by this method.

I-b-7-5 - Studies of DDT and other materials for soil treatment for control of the grape phylloxera. To develop effective, practical control of the grape phylloxera on the roots of grapevines by use of DDT and thus stop the serious decline that is affecting many vineyards of susceptible European type grapes.

I-b-7-6 - Fig caprification studies. To determine the best method of distributing the pollinating wasp (Blastophaga) in fig orchards, including timing of distributions and the arrangement of the caprifig containers in the trees and in the orchard to give the best possible results in pollination, with a minimum of fig spoilage caused by the organisms that are disseminated by these wasps.

I-b-7-7 - Biological studies of dried fruit insects affecting date production. To secure basic information on the biology, habits, and seasonal history of the insects responsible for damage to dates in the southwestern United States, as a basis for the development of adequate control measures.

I-b-7-8 - Control of insects affecting date production. To prevent insect damage to dates in the southwestern United States by devising and developing ways and means of controlling the insects responsible.

I-b-7-10 - Studies of the biology and control of miscellaneous insect pests of dried fruits and fruits intended for drying. As opportunity offers, to study the numerous insect pests that attack dried fruits or fruits intended for drying to obtain information on their biology and to develop methods of control.

I-b-7-11 - Control of spoilage in figs caused by insects and insect-borne diseases. To reduce the heavy losses resulting from these types of spoilage. A survey made in 1948 by the California Fig Institute showed that 1,448 acres of orchards in 13 counties were recently removed, mostly because of inability to control spoilage.

C. History and Evolution of This Work

The first project of major importance affecting dried fruits was the importation and establishment in California of the fig pollinating wasp (Blastophaga), during the period 1897-1900. This wasp is essential to the production of figs of the Smyrna type. From 1911 to 1915 workers stationed in California did more or less general work with the insects affecting dried fruits. After a lapse of several years work was resumed in 1921 and has been virtually continuous ever since. It included studies of the biology of most of the important dried fruit insects, and the development of methods for their control, especially fumigation. The early work was chiefly concerned with pests infesting the dried fruit in packing house or warehouse. After a decade, however, it was realized that infestations of certain important pests start in the field and are brought into the warehouses with the new crop. The work was therefore extended to the field and was soon broadened to include problems such as those involving the grape phylloxera, the grape leaf folder and similar insects that affect the production of fruit intended for drying.

D. Funds--Annual Expenditures

Accurate figures on expenditures are not available for the work prior to fiscal year 1921. Expenditures in 1896 to 1900 may have been as much as $2,000 a year and from 1911 to 1915 as much as $4,000 annually. The average annual expenditures for the three decades following 1920 were about as follows: $7,000, $14,000 and $17,000. The allocation for the fiscal year 1950 was about $18,000.

E. Examples of Outstanding Accomplishments

Importation of the fig pollinating wasp permitted development of California fig industry. The Smyrna type of fig, the kind used chiefly for drying, requires for its development fertilization by a tiny wasp known as Blastophaga. During the latter part of the last century plantings were made of this type of fig in California but the results were disappointing. After several efforts by private industry to import this wasp had failed, the Department succeeded in introducing and establishing it in the fig-producing areas of California, during the period

1897-1900. The wasp has thrived in California and growers have little difficulty in securing adequate pollination. Without this introduction the production of the Smyrna type of fig would have been impossible.

Department workers pioneered in the development of fumigation for controlling dried fruit insects, and introduced several of the newer fumigants to the fig industry. Important contributions were made to the development of ethylene oxide and methyl bromide as fumigants for dried fruit insects. Stocks of dried fruits in warehouses must be treated to prevent attack by many kinds of insect pests, and methyl bromide is now in almost universal use in the dried fruit industry for that purpose.

A motor driven shaker screen devised by Department entomologists to remove infestation by raisin moth just before the raisins are moved from the ranch to the central warehouse. The raisin moth attacks raisins when they are drying in the field, especially after the trays have been stacked. This device permits the growers to deliver a clean product to the warehouse, which has caused a decided improvement in the condition of the fruit brought in.

Fig growers provided better methods of controlling fig scale as a result of the work of Department entomologists and cooperating state workers. This insect causes blemishes on the fruit which are especially serious on figs intended for canning or preserving. Several types of oil sprays put on during the dormant period give satisfactory control. Recently, parathion applied early in the growing season was found to effect a high degree of control. This permits the growers to deliver a cleaner and, therefore, much more profitable crop to the processing plants.

F. Some Additional Work Needed

Studies of so-called systemic insecticides needed. In the last few years several insecticides have been developed that are carried by the sap to all parts of the plant and are poisonous to insects that feed on treated plants. They can be applied to the leaves of the plant or to the soil. Preliminary results suggest the possibility of using such materials to improve control of the grape phylloxera which infests the roots and to provide possible better control of some other pests attacking fruits intended for drying.

More work needed on the prevention of fig spoilage. Fig growers often have to cull out 25 percent or more of the crop because of spoilage caused by various organisms, many of which are carried into the figs by insects. Much more intensive work is needed as efforts to prevent this type of damage have thus far been only partially effective.

Effect of cold storage on dried fruit pests. Temperatures below 50 degrees prevent activity of most insects that infest dried fruits, and lower temperatures continued for varying periods, depending on the species, will finally kill all stages. Considerable information has been accumulated on this subject but it has been necessary to use for the most part temperatures available in commercial storage. More complete studies covering the full range of temperatures that might be used is needed for each of the important species of dried fruit pests in order that more definite recommendations to the industry may be possible.

Insect proof packages needed. Packaged dried fruits held at ordinary temperatures are subject to invasion by a number of the insects that commonly infest stored food products. These insects are able to pass through a very tiny space and once in the package not only contaminate or destroy the product but also destroy customer good-will. Types of packages or methods of sealing packages to exclude such pests need to be developed so that packaged dried fruits held in warehouses, on dealers shelves, and in similar situations may remain free of infestation.

GRAPE PRODUCTION, DISEASES, AND IMPROVEMENT
(BPISAE b-1-3 - Federal-State--Regular Funds)

A. Purpose and Nature of Current Work

To (1) breed disease-resistant table grapes for humid regions of eastern States; (2) breed improved table and raisin grapes for western States; and (3) select the best stocks for grapes for nematode, phylloxera, and root-rot resistance. Current work in the Southeast is particularly concerned with the origination of muscadine varieties that are perfect-flowered. The breeding work for northeastern States is to originate disease-resistant grapes, particularly for home use, that can be grown without the repeated spraying now necessary. The current work in western States is to breed improved raisin, table, and shipping grapes. Quicker and more economical ways of evaluating seedlings from the breeding work are also being investigated.

B. Currently Active Line Projects

b-1-3-1 - Breeding disease-resistant, hardy grapes for humid areas. To originate grape varieties resistant to black rot and mildew in northeastern areas, and to breed perfect-flowered muscadine varieties for southern States so that crops can be produced without special provision of growing male vines which do not produce fruit.

b-1-3-2 - Breeding improved table and raisin grapes for western States. To originate improved table and raisin grapes for California and other western States which will be especially suited to the climatic conditions of the different western grape-growing areas.

b-1-3-3 - Evaluation of grape rootstocks for nematode, phylloxera, and root-rot resistance. To continue selection of grape rootstocks for the different varieties, which will be resistant to the nematode, phylloxera, and root rots in the different areas in California and adjacent States.

b-1-3-4 - Adaptability of grape varieties to different sections of the United States. To determine by vineyard tests and observation and study the varieties adapted to the different areas as regards hardiness, disease resistance, and yielding ability.

b-1-3-5 - Soil management and fertilizer practices in vineyards to improve yield and quality in bearing vineyards. To determine the best means of weed control and fertilizer practice to obtain the maximum yield and best quality in bearing vineyards.

b-1-3-6 - Effect of different pruning practices on growth and yield. To determine particularly for new varieties the pruning practices that will give the highest yields of the best fruit in different areas.

b-1-3-7 - Virus diseases of grapes. To study the different virus diseases that cause losses in grape vineyards, particularly in California.

b-1-3-8 - Little-leaf, measles, and other physiological diseases. To determine the cause and best methods of control of the various troubles found in different vineyards in different parts of the United States.

b-1-3-9 - Soils, fertilizers, and soil-management practices most suitable for muscadine grape production. To determine the best methods of weed control and best methods of maintaining fertility in vineyards in southeastern States.

C. History and Evolution of the Work

Studies of the best grape varieties and best rootstocks for the different varieties were begun in the early 1900's in California and studies on muscadine grapes were started about 1910 in southeastern States. After it was found that phylloxera, a form of root lice on grapes, was one of the important causes of weak vines and losses in California, attention was then focused on the testing of rootstocks from all over the world to obtain vigorous ones resistant to phylloxera and later to nematodes. Later studies of varieties indicated the need of better early and late varieties of shipping grapes in California and similar studies in southeastern States indicated the need of perfect-flowered varieties which would eliminate the need of non-fruiting male vines used for pollination purposes only and these objectives were sought in the breeding program begun in 1907. More recently attention has been turned to the breeding of disease-resistant table grapes which could be grown both in home gardens and in commercial vineyards in the eastern region of the United States.

D. Funds -- Annual Expenditures

The annual expense from about 1900 to 1910 was approximately $30,000; since 1910 the annual expenses ranged from $30,000 to $38,000 in 1940, $63,630 in 1949, and $54,130 for 1950.

E. Examples of Outstanding Accomplishments

Introduction of perfect-flowered muscadine grapes for the Southeast. As the result of the breeding work of the Department of Agriculture, the Burgaw, Duplin, Pender, Tarheel, Wallace, and Willard perfect-flowered muscadine grape varieties have been introduced for the southeastern States, making it possible for home gardeners to have one vine that will set good crops of fruit in their dooryard, and for commercial plantings to consist of one variety only. Male vines that bear no fruit need not be planted for pollination purposes. Burgaw is one of the best of these perfect-flowered varieties.

Introduction of improved vinifera table shipping grapes for western States. Two varieties, the Cardinal and Calmeria, have been introduced in California; the Cardinal introduced in 1946 is about three weeks earlier than any shipping variety; the Calmeria introduced in 1950 is the latest shipping variety, to replace the Almeria or Ohanez, a self-sterile, relatively unproductive variety. These two varieties are already proving of commercial value in California and adjacent States and thousands of acres have already been planted.

Introduction of phylloxera- and nematode-resistant rootstocks. As the result of the Department's work in testing the various stocks for resistance to phylloxera and nematodes, half the acreage in California is on resistant rootstocks and for most new plantings resistant stocks are used. They should be used far more widely in the important grape areas. In many areas the increase in yield due to rootstocks may average three tons per acre. The better stocks for general use are Rupestris-St. George as the standard phylloxera-resistant stock and Solonis x Othello 1613 as a stock highly resistant to root-knot nematode also.

Control of little-leaf and poor setting. Different varieties of vinifera grapes in California have produced extremely loose clusters with poor fruit-set in many commercial vineyards. Even though they may show no evidence of little-leaf, a symptom of zinc deficiency, these vines when brushed or sprayed with a solution of zinc-sulfate immediately after pruning, gave approximately twice the yield of fruit. This method of increasing yields developed by Department workers has become a standard practice. Publication on regional adaptability of varieties: "Grapes for Different Regions," Farmers' Bulletin 1936.

F. Some Additional Work Needed

Perfect-flowered, disease-resistant muscadine grapes. Although high-flavored, fairly productive, perfect-flowered varieties have already been obtained by breeding, this work needs continuing to originate such large-fruited, disease-resistant ones that the imperfect-flowered ones can be discarded.

Disease-resistant, high-flavored "bunch" grapes. There are varieties, though of poor quality and grown but little, so resistant to black rot and mildew that spraying with fungicides is unnecessary. Varieties of eastern grapes should be bred combining such exceptional disease resistance with high flavor and good commercial qualities for table and juice uses. Greatly increased size, flavor, and keeping quality can also be obtained by crossing the California type with resistant Eastern varieties.

Improved shipping, seedless, and raisin grapes. Though the Cardinal and Calmeria varieties fill the needs for the very early and very late table grape seasons in California, similarly good shippers are needed for the rest of the season; also seedless grapes to extend the season of Thompsons Seedless, and kinds that will produce higher flavored raisins.

Improved rootstocks for California grapes. Though good stocks highly resistant to phylloxera and root-knot nematode have been found very valuable and are being used extensively, stocks resistant to both these diseases and also to alkali and root diseases should be bred.

Quick methods for testing disease resistance needed. With strawberries it has been found possible to test 25,000 seedlings for red stele resistance in a 30' x 30' greenhouse section in winter more accurately and in less than one-fifth the time that field tests require. Research is needed to devise similar tests for resistance to black rot, mildew, and anthracnose of grape to hasten and lessen the cost of breeding for resistance to these diseases.

INVESTIGATIONS OF GRAPE AND OTHER SMALL FRUIT PESTS IN THE EAST
(BEPQ - No. I-b-8 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to develop more effective, economical, and practical methods of controlling the numerous insects attacking the grape and other small fruits in eastern United States which cause serious losses to growers. The work at this time concerns the development of effective methods of controlling the grape berry moth which will not leave objectionable spray residues on the fruit. Studies are conducted to develop more effective and satisfactory methods of controlling other insect pests of the grape, and pests of certain small fruits, including cranberries, blueberries, currants and gooseberries. Continued effort is necessary to improve control methods for many of the grape and small fruit insect pests because certain of the methods in current use are not entirely satisfactory.

B. Currently Active Line Projects

I-b-8-1 - Experiments in control of grape berry moth with insecticides. To develop a more practical insecticidal program for control of the grape berry moth that can be used with grape fungicides without leaving objectionable residues on the fruit.

I-b-8-2 - Experiments in control of grape berry moth by cultural methods. To develop methods of controlling the grape berry moth by cultural methods such as plowing at the proper time to bury the cocoons.

I-b-8-3 - Investigations on control of grape insects other than the grape berry moth. To develop improved control measures for grape insects other than the grape berry moth, and to make incidental studies and observations on the biology of these insects as a basis for the development of control measures.

I-b-8-4 - Grape spray residue studies. To determine the relationships between spray programs for grape berry moth control and the residues on the harvested grapes and in grape products such as wines, juices, jams, and jellies.

C. History and Evolution of This Work

Grape insects were given some incidental attention by Federal entomologists during the early years of the Department's existence but detailed investigations in the east were not undertaken until 1907 when the serious injury caused by the grape rootworm in the Lake Erie grape belt led to the establishment of a laboratory there. Intensive work on this insect was carried on for a few years. The grape berry moth, rose chafer, grape leafhoppers, and other insects were also given serious study. Grape berry moth studies have been pursued continuously since 1917, because of the urgency of the problem and the lack of entirely satisfactory methods for controlling this insect. Some attention has been given for short periods to grape insects in other areas where serious local problems have developed.

The serious damage done by the blueberry maggot in eastern Maine led to investigations of this insect in that area from 1925 to 1932, inclusive. After some incidental observations on cranberry insects at various locations, a laboratory was established in Wisconsin in 1908 because the control measures used by growers in Massachusetts and New Jersey were not effective in Wisconsin. In 1913 the cranberry insect investigations were transferred to New Jersey, where they were continued until 1917.

Although current work under this project is restricted to eastern United States, it included studies of the grape phylloxera and grape mealybug in California, and cranberry insects in Washington, early in its history. Federal work on cranberry insects was discontinued at the close of 1919.

D. Funds--Annual Expenditures

Only occasional nominal sums from general allotments for insect work, perhaps never more than a few hundred dollars in any single year, were expended for grape and small fruit insect studies prior to 1907. From 1907 to 1913, amounts expended from general funds for grape insect work probably averaged no more than $5,000 per annum. From 1913 to 1949, the yearly expenditures averaged a little more than $7,000. In the fiscal year 1950, the allocation for this activity was approximately $10,500. The annual expenditures for cranberry insect work during the period 1913 to 1920 averaged about $3,000 per year. Only nominal amounts were spent prior to 1913. The average amount expended for the blueberry maggot project during the eight years of its existence (1925-32) was approximately $8,900 per year.

E. Examples of Outstanding Accomplishments

Important contributions made to our knowledge of the biology of grape insects in eastern United States and to the development of practical methods for their control. The biological information accumulated by Department entomologists through many years of study is of inestimable value to research entomologists throughout eastern United States. Whenever new insecticides become available, their prompt evaluation on a sound biological basis is facilitated. The grape insect control methods developed, even though crude at first and in some instances never entirely satisfactory, helped commerical grape growers to produce profitable crops and by virtue of this service contributed to the development of the present extensive grape production and processing industry.

DDT spray programs developed for grapes. DDT is the most effective material yet discovered for controlling grape leafhoppers, rose chafer, grape rootworm, and grape berry moth. A practical DDT spray schedule was developed for use in northern Ohio. The benefits to grape growers have been the practical elimination of the serious grape leafhopper problem and of destructive outbreaks of the rose chafer and grape root worm, which occasionally occurred in earlier years. The DDT also gives vastly improved control of the grape berry moth, with increased returns to the growers even though the extent to which this material can be used in second brood sprays is limited by the necessity for avoiding objectionable amounts of DDT residue on the grape berries at harvesttime.

Important contributions made to the development of a cultural method for grape berry moth control. Systems of cultivation were developed to destroy the wintering forms of the grape berry moth on the ground along the trellis row, by covering them with a compact layer of soil. These methods are now widely used by growers in the Great Lakes area. Modifications of existing grape hoes help accomplish this purpose. With careful attention to these cultural practices each year, the severity of the grape berry moth problem can be greatly reduced, making the insect much easier to control with standard spray programs.

Means of combatting blueberry maggot developed. By dusting the blueberry fields in Maine with calcium arsenate it was possible to reduce the maggot infestation 95 to 99 percent. This permits growers and canners to market a crop substantially free of maggots. The actual value of the blueberry crop in normal times in Maine is more than $1,000,000. The general use of calcium arsenate dust has resulted in at least a 10 percent saving to the growers. Many of the more heavily infested blueberry fields in Maine were left unharvested before the development of this control method.

Surveys and studies of the life histories and habits of cranberry insects in New Jersey, Wisconsin, and Washington. Valuable biological data secured during the period 1908 to 1919, inclusive, has provided a sound basis for the development of practical insecticidal and cultural control methods, and their effective application by growers.

Important contributions to cranberry insect control. These include the development of nicotine sulfate for black-headed fireworm control and an evaluation of the uses and limitations of control by the flooding method. The nicotine sulfate treatment benefited cranberry growers particularly in Washington, where most of the bogs could not be supplied with enough water for flooding purposes. In the flooding work the recommended dates and periods for flooding cranberry bogs to control a number of serious insect pests were evaluated in field tests. The improvements in flooding schedules resulting from this work were of great value to the growers during the early developmental period of the cranberry industry.

F. Some Additional Work Needed

Better materials and spray programs needed for controlling the grape berry moth. The amount of DDT which can be used on grapes during the period of second brood grape berry moth activity is limited by the necessity for avoiding excessive residues at harvest time. The result is that spray schedules are not always as effective as they should be. The DDT also kills parasites and predators which control other pests not affected by DDT. Another objectionable feature is the great stability of DDT which may allow it to accumulate in the soil in injurious amounts. The evaluation of new insecticides and tests of spray programs should be continued until these important objections to the present standard control measures are overcome.

Investigations on control of small fruit insects other than the grape berry moth should be conducted. In the eastern United States there are a number of different insects which often become destructive pests of small fruits when conditions are favorable for their development. Fully adequate control measures are available for relatively few of these insects. Information on the value and limitations of the newer insecticides, and their compatibility with the required fungicides, for controlling many of these miscellaneous small fruit insect pests is needed.

Experiments should be made on control of the grape berry moth by cultural methods. The present cultural method of control has not been completely evaluated with respect to the advantages which may accrue during long periods of usage. Chemicals now being investigated for weed control in vineyards show promise of being effective against the overwintering pupae of the grape berry moth on the soil along the trellis rows. A full investigation of the possibilities of these weed killers with respect to grape berry moth control and the development of information on the most effective materials, concentrations, dosages, and schedules for application are needed.

Further spray residue studies needed. The problem of residues resulting from applications of lead arsenate, DDT and other insecticides, both on small fruits and grapes grown for fresh food and in products such as wines, juices, jams, and jellies is one that deserves serious attention. The spray programs that have been developed give residues that are usually under the tentative administrative tolerances for apples and pears, but when infestations are severe and late applications are required, the residues are apt to be excessive. Analyses of lead, arsenic, DDT and parathion in wines made from grapes show that most of these chemicals are eliminated in the pressing amelioration and fermentation processes and that the wines are safe for consumption. Similar studies with respect to other products and new promising insecticides are needed.

The problem of residual accumulations of insecticides in vineyard soils needs investigation. The effect of insecticides in the soil on the vines, and the development of means of avoiding or neutralizing injurious accumulations also need serious attention.

SMALL-FRUIT PRODUCTION, DISEASES, AND IMPROVEMENT
(BPISAE - b-1-4 - Federal-State—Regular Funds)

A. Purpose and Nature of Current Work

To (1) originate new varieties of berries which will produce maximum yields of qualities desired for home garden and commercial use under the many prevailing conditions as affected by soils, climate, insects, diseases, and cultural and harvesting practices; (2) devise new practical methods for increased, improved, or cheaper production; and (3) to devise improved practices for control of diseases. Because of the shorter time of getting berry seedlings into fruiting as compared with apple and pear seedlings, relatively greater emphasis is placed on breeding varieties resistant to disease than on methods of disease control.

B. Currently Active Line Projects

b-1-4-1 - Breeding strawberries for improved quality, adaptation and disease resistance. To originate varieties resistant to red stele-root disease, with frost-hardy flowers, with firm texture for shipping, with higher flavor and aroma, and adapted to the frozen pack trade.

b-1-4-2 - Breeding raspberries and blackberries for improved quality, adaptation and disease resistance. To originate varieties of raspberries resistant to bud injury from cold, resistant to cane and leaf diseases, adapted to frozen pack use and adapted to the South as well as to the North. To originate varieties of blackberries without thorns, of high flavor, adapted to the frozen pack trade, resistant to cane and leaf diseases and with small seeds.

b-1-4-3 - Breeding blueberries for improved quality, adaptation and disease resistance. To originate varieties of better flavor, better shipping quality, greater heat and cold resistance, and resistant to the canker disease.

b-1-4-4 - Breeding cranberries for increased yield and resistance to false-blossom. To originate varieties of cranberries resistant to the false blossom virus disease and adapted to each of the cranberry regions of the country; that will have high color, earliness of maturity to escape fall frost, and larger size.

b-1-4-5 - The adaptation of berry varieties to various regions. By testing in different regions of the United States and by observations, to determine as accurately as possible the adaptation of the different varieties to the different regions.

b-1-4-6 - Breeding for resistance to red stele and other root diseases of strawberry. To originate varieties resistant to the red stele-root disease, especially adapted to the regions of the United States where this root disease is serious.

b-1-4-7 - The most economical practices in the management of berry plantings--to increase production and improve quality. To test methods of weed control, to test the fertilizers that are needed in the growth of the plant and fruit, and to devise other practices for increased production and improved quality that are economical to use.

b-1-4-8 - Increasing the yield of blueberry by cross pollination. To determine the value of cross pollination of the different varieties and species of blueberry for the different areas of the United States where blueberries are grown.

b-1-4-10 - Spoilage in cranberries. To test fungicides that may be useful for controlling fruit rots of cranberries.

b-1-4-11 - Stunt disease of blueberry. To determine the relative susceptibility of varieties of blueberries to this disease and by breeding to obtain varieties highly resistant to it.

b-1-4-12 - Cranberry injury caused by protective winter flooding practices. To study the injury to the cranberry plant and crop caused by oxygen deficiency in the water used for flooding cranberry bogs for winter protection and to devise methods for growers of avoiding injury by oxygen deficiency during the winter.

b-1-4-13 - Studies of minor elements in strawberry. To determine whether strawberries on any soil types are deficient in minor elements and to devise methods of applying minor elements that will give increased yields.

b-1-4-14 - Soil management and fertilizer requirements of strawberry—to increase yield and improve quality. To study rotation of crops and to soil-improving crops in the rotation with the strawberry, and to devise fertilizer practices to increase yields and improve the fruit quality.

b-1-4-15 - Strawberry and raspberry root-rot disease investigations in the Pacific Northwest. To study particularly root-rot diseases of the strawberry other than the red stele-rot disease, and to determine the cause of root rot of raspberry in the Pacific Northwest.

C. History and Evolution of This Work

Studies on methods of controlling diseases of the cranberry started in the early 1900's. Breeding of blueberries started about 1908. Breeding of improved varieties of raspberries, blackberries, and strawberries began in 1919. The breeding of cranberries began about 1929. Recent work with the strawberry has centered around the origination of firm, large, high flavored, hardy varieties resistant to the red stele-root disease, which is so serious in northern areas, both in eastern and western States.

D. Funds — Annual Expenditures

The annual expenditures from about 1900 to 1910 ranged from $5,000 to $15,000; from 1911 to 1920 from about $20,000 to about $50,000; since 1920 the annual expenditures have varied from $50,000 up to in 1930, $58,000 in 1940 to $66,140 for 1950.

E. Examples of Outstanding Accomplishments

Blueberry varieties. All of the blueberry varieties used in the present cultivated blueberry industry and most of the cultural methods followed have been developed as a result of Department's research. The 1949 farm value of the blueberry crop from cultivated acreage was ~~$2,500,000~~ 3,000,000; the 1950 value about $4,500,000. Native wild blueberries were selected, crossed, and recrossed, to give us the large-fruited, high-flavored, productive varieties. Four of the most outstanding varieties (Coville, Berkeley, Murphy, and Wolcott) were introduced in 1949.

Strawberry varieties important. The first of the Department's strawberry varieties introduced was the Blakemore and it now constitutes over one-third of the total crop of the country. It is liked because of its excellent shipping qualities. The Department also has originated the Temple and Fairland varieties, two of the successful red stele-resistant varieties that make it possible to grow strawberries in soils infested with the red stele root disease. Other varieties resulting from the breeding work are Brightmore, Massey, Maytime, Redstar, Starbright, Midland, Fairpeake, Fairfax, Suwannee, Southland, and Fairmore. The acreage of all varieties originated by the Department is about 40 percent of the total valued at $32,000,000.

New raspberry variety for the Northwest. The Willamette variety, introduced by the Department in 1943, is being more widely grown each year because of its greater cold hardiness, its larger fruit size, compared with Cuthbert, and its excellent processing quality.

New improved cranberry varieties. The Department has just introduced three new cranberry varieties, Beckwith, Stevens, and Wilcox, selected as a result of its breeding for better varieties and varieties resistant to the false-blossom virus disease. Many additional selections from this breeding are still under test.

Cranberry diseases controlled. The cranberry disease control program for practically the whole industry of the United States has been developed by our disease specialists. In many areas it would be impossible to grow the cranberry except for this control program. In addition, it has been found that much of the poor crop in some years was due to oxygen deficiency of the water which was used for flooding cranberries in the winter for cold protection. Methods have been devised to tell when the oxygen in the water is low enough to cause cranberry smothering, and methods have been devised for control of this oxygen deficiency. This work alone has enabled growers in Wisconsin to nearly double their annual yields and has helped greatly in the Massachusetts and New Jersey cranberry sections to control loss from oxygen deficiency.

Extent of strawberry virus diseases established. Until recently it was thought that there was no virus problem in strawberries in eastern States. However, through the work of the Department specialists it has been shown that strawberry virus diseases have gotten into most of the stocks of strawberries in the eastern United States and that they cause very serious losses, even though the symptoms of the diseases are not so plain as with virus diseases of other plants or of the strawberry on the Pacific Coast.

F. Some Additional Work Needed

Origination of frost-hardy-flowered strawberries. Crosses of a wild strawberry with flowers standing more than 10° more frost than our ordinary varieties indicate that desirable commercial varieties with frost-hardy flowers can be bred. The annual loss from frost probably amounts to a million dollars annually and this work needs completion.

Red stele-resistant strawberries. Though two varieties from the Department's breeding work and two from New Jersey Experiment Station have been introduced that are resistant to the red stele root rot, varieties for other regions of the country that suffer severe loss from this disease need to be originated. Recently also a strain of the red stele root disease has appeared to which the four above mentioned resistant varieties (being grown commercially) are susceptible. Varieties resistant to this new strain of the disease need to be bred.

Improved varieties with higher aroma, larger size, higher vitamin C content, and greater firmness needed. Commercial varieties can be greatly improved by combining the finest aroma, largest size, highest vitamin C content, and greatest firmness of strawberries into disease resistant, productive ones adapted to each section.

Breeding thornless blackberries possible. Tests only this year have indicated that it is possible to cross a large-seeded, fair-flavored, nonhardy, thornless blackberry with our hardy, high-flavored varieties so as to get fine thornless varieties to be grown by industry and by home gardeners. This line of breeding work should be followed up as promptly as possible. Some of the first generation seedlings from such a cross have relatively small seed, fine flavor and are productive.

Better-keeping blueberries needed. Spoilage of blueberries on the market is due to a large extent to the tearing of the flesh and skin when they are picked from the stems. There are some varieties that tear only a little when picked, and an effort is being made, and should be followed up, to obtain a series of varieties that do not tear when picked and that will keep far better when placed on the market.

Spoilage of cranberries in the field. Adjoining cranberry bogs and different areas in a single bog produce berries that keep very differently. Some keep well, others spoil in the field. An understanding of the conditions that affect the keeping quality of the cranberry is needed and may make it possible with very little expense to make good-keeping berries of all cranberry crops from all areas. This spoilage is especially severe in New Jersey but occurs also in the Massachusetts cranberry areas.

VIRUS DISEASES OF STRAWBERRIES
(BPISAE - RM:b-530 - Federal-State—RMA Funds)

A. Purpose and Nature of Current Work

To isolate, increase, and maintain strawberry planting stocks free of virus diseases for foundation stocks for nurserymen and growers. The current work is primarily concerned with testing vigorous stocks of varieties from every part of the United States in the attempt to obtain clean stocks and to obtain information on action necessary to keep stocks clean. Any tested plants that are clean are propagated as foundation stocks.

B. Currently Active Line Projects

RM:b-530-1 - Isolate, increase, and maintain strawberry planting stocks free of virus diseases. To obtain planting stocks free of virus diseases and provide foundation stocks for nurserymen and growers.

C. History and Evolution of This Work

General studies which have been under way for about 10 years, have shown that most stocks of strawberries in eastern United States are infected with virus diseases. This project was organized in the summer of 1949 to isolate, increase, and maintain strawberry planting stocks free of the diseases. This work needs to be continued until stocks of as many as possible of our important varieties are found free of disease and until such stocks are propagated and can be maintained free of these troubles.

D. Funds — Annual Expenditures

The appropriation for 1950, the first year of operation, was $18,400.

E. Examples of Outstanding Accomplishments

Finding of disease-free stocks. Stocks of at least 15 varieties have already been found free from virus diseases and these have been put in the greenhouse and propagations started. We may expect that within about three years stocks of these will be available for general distribution and commercial propagation. In addition, more than a thousand grafts have been made in testing vigorous stocks with indicator plants. Plants of many other kinds are probably free from virus but it will take some little time yet to determine this fully.

New disease indicator found. It has been found that Fragaria vesca, the native European wood strawberry, shows virus in three to six weeks after its runners are grafted to runners of infected plants. This makes it possible to determine whether a plant has virus in a much shorter time than formerly.

F. Some Additional Work Needed

Search for immune parental material and breeding to obtain varieties immune to virus. One selection of our eastern meadow strawberry seems to be immune to virus. So far, no virus has been found in it. In Canada, tests by one of the workers there indicated that some selections of the native meadow strawberry were immune to virus. If this is properly checked and found to be true, it may be possible to use these in the regular work of breeding immune varieties for permanent control of such diseases.

Separation and identification of strawberry viruses. In order to properly understand the viruses of strawberries, it is essential that methods of separating the different varieties and identification of them be found so that if there is a possibility of breeding for resistance to the viruses this can be accomplished. At the present there is little knowledge of the kinds of viruses that are present in strawberry stocks and it seems impossible to breed for resistance to them until we have this knowledge.

Sources of viruses and keeping healthy stocks clean. Surveys should be made of the wild strawberries to determine whether virus exists in native strawberries growing in the wild and might spread to cultivated varieties. Tests should be made in strawberry propagating areas to determine conditions necessary for keeping stocks clean.

Foundation stocks. Though virus-free plants of some strawberry varieties have been found, clean stocks of all varieties should be built up as foundation stocks for nurserymen. This should greatly increase production of strawberries in many sections.

Immunization by use of mild strains of virus. In the peach it seems to be possible to put a mild form of virus into a cultivated variety and the mild form will cause no loss of crop but will immunize against the severe form of the same virus. Thus it is possible to grow peaches that could not be grown because of the effect of the severe virus. The same procedure might be applied to strawberries when strains of the viruses have been separated. If it is not possible to eliminate virus from strawberry plantings, a method may thus be found to grow strawberries in spite of virus diseases.

Killing virus in plants. Tests should be continued to see if through use of chemicals or heat, affected plants may be freed from the virus.

Other host plants. Continued tests of other possible host plants of the virus should be made, particularly those related to the strawberry, such as rose or blackberry.

EDIBLE TREE NUT PRODUCTION, BREEDING AND DISEASE INVESTIGATIONS

(BPISAE - b-3-5 - Federal-State-Regular Funds)

A. Purpose and Nature of Current Work

To (1) determine the basic principles governing the growth and fruiting of pecan, walnut, almond, filbert, chestnut, and other edible tree nuts, and how they are affected by differences in soils, fertilizers, culture, pruning, irrigation, and pollination; (2) determine the causes for and practical control of diseases; (3) develop by breeding new high-yielding disease-and insect-resistant varieties producing well-filled, high-quality nuts; (4) devise and test methods of asexual propagation of varieties; and (5) test the suitability of understocks. The current work is particularly concerned with solving the critical problems of growers which at present limit production or result in very high costs per pound of nuts, and is outlined below:

B. Currently Active Line Projects

b-3-5-1 - Pecan production. To develop methods of increasing yields, and the quality of the nuts produced, through improvements in orchard management practices.

b-3-5-2 - Breeding and testing of new pecan varieties. To develop new varieties of pecan which are resistant to disease, prolific, and adapted to production and market requirements, especially as to kernel quality and suitability for commercial shelling.

b-3-5-3 - Control of pecan diseases. To determine methods of control and the best materials to use; to test equipment for applying them; to devise or improve other practices which through protective treatments, sanitaton, or eradication will control pecan diseases and result in the largest net return to the grower.

b-3-5-4 - Mineral nutrition of pecans. To determine the relationship between the mineral composition of pecan leaves and the growth, yield, and quality of the nuts produced, in order to find the optimum level of each essential element and the balance (ratio) between elements that results in the largest yields of high-quality, well-filled nuts.

b-3-5-5 - Maintenance of fertility in pecan soils. To determine the effects of different methods of culture, cover crops, and fertilizers on the level of soil fertility supplied to the trees and to develop methods of maintaining the fertility under suitable orchard conditions, whereby the trees will make satisfactory growth and yield profitable crops of high-quality nuts.

b-3-5-6 - Thinning the nut crop by spraying with chemical solutions. To develop methods of thinning the crop on over-producing pecan trees by spraying them with chemicals that will result in more uniform production of higher quality and better filled nuts than is obtained from alternate bearing trees.

b-3-5-7 - Breeding and testing of new almond varieties. To develop new almond varieties that are resistant to disease, prolific, adapted to production and market conditions, especially as to kernel quality and suitability for commercial manufacturing processes.

b-3-5-8 - Walnut tree growth and productiveness. To increase the yield, improve the quality of the nuts, and lower the cost of production through improvements in walnut orchard management practices.

b-3-5-9 - Filbert tree growth and productiveness. To develop improvements in filbert orchard management practices that will increase the yield, improve the quality of the nuts, and lower the costs of production.

b-3-5-10 - Cause and control of filbert diseases. To determine the nature, causal agent of the disease, and to devise and test methods of control through protective treatments, sanitation, or other methods which will result in the largest net return to the grower.

b-3-5-11 - Cause and control of walnut diseases. To determine the nature, causal agent of the disease, and to devise and test methods of control through protective treatments, sanitation, or other methods, which will result in the largest net return to the grower.

b-3-5-12 - Filbert breeding, selection, and variety testing. To develop new, hardy filbert varieties for the northeast by hybridization of the native American filbert (hazelnut) with the European filbert.

b-3-5-13 - Chestnut breeding, selection, and variety testing. To develop new varieties of chestnut for nut production that would not only be suitable for home planting but which would make commercial production possible.

b-3-5-14 - Walnut breeding, selection, and variety testing. To develop new hardy, heavy-bearing, thin-shelled walnut varieties having the hulling and cracking quality of the Persian (English) walnut, and the flavor and cooking quality of the eastern black walnut.

C. History and Evolution of This Work

Probably the first research work on tree nuts was started in 1902 to determine the cause and control for the pecan disease known as rosette. It was not until 1932, or 30 years later, that it was found to be a zinc deficiency. Work on this and other diseases was continued intermittently until about 1920 when the research program was enlarged to include work on production problems with pecans, the breeding of new almond varieties, and the problem of pollination of the Persian (English) walnut on the West Coast. By 1930 the disease and production problems of the pecan and Persian walnut had become so critical as to threaten these industries; as a result the scope of the research work was greatly broadened and enlarged. This was followed by investigations on methods of disease control and improvements in production practices that have not only made it possible for the growers to stay in business, but have led to the establishment of many new orchards and have brought domestic tree nut production to an all time high.

D. Funds -- Annual Expenditures

Estimates for the early years are difficult to obtain. A very rough estimate of annual expenditures from 1902 to 1929 ranged from $6,000 to $40,000. From 1930 to 1939 the costs have ranged from approximately $55,000 to $160,000 and have averaged about $125,000. From 1940 to 1949, the costs have ranged from approximately $110,000 to $160,000 and have averaged about $135,000. For the fiscal year 1950 $153,560 was allotted.

E. Examples of Outstanding Accomplishments

Pecan rosette found to be caused by zinc deficiency. Although the disease condition of pecan trees known as rosette was called to the attention of the Department in 1902 and work was started then, by 1930 it was estimated that 60 percent of all bearing trees in orchards were affected. In 1932, this disease was found to be caused by a deficiency of zinc and readily corrected by application of zinc in suitable forms and by proper methods. This discovery furthered the development of the pecan industry and has meant millions of dollars of income to pecan growers.

Control of walnut blight or bacteriosis. The disease of Persian walnut known as blight or bacteriosis caused such high losses that a growers' association offered a reward of $25,000 for a satisfactory method of control. Highly effective and economical control measures were devised which, when applied properly, will result in 95 to 98 percent control even under the most severe conditions.

New almond varieties fill important place. Two hybrid almond varieties adapted to California have been developed cooperatively and extensive plantings have been made. One of these, the Jordanola, has become most important because of its heavy production and superior quality. The Jordanola has regained a special fancy market that was lost to American growers because of lack of a suitable variety to meet this demand. Other new varieties for the candy-bar trade now under test are to be released in the near future to fill a demand for large quantities of nuts for this special purpose.

Borax treatment corrects Persian walnut disorder. Research showed that most of the Persian walnut orchards of the Pacific Northwest are deficient in boron. A disorder caused by this deficiency was known for more than 20 years. It was called variously dieback, snakehead, baldhead, and winter-kill. Applications of borax to the soil around the trees has resulted in greatly increased yields and higher quality of the nuts produced. As an example, trees after treatment have averaged 185 pounds of nuts per tree while similarly affected untreated trees yielded 29 pounds.

Effective control for pecan scab results in increased profits. Methods for the control of pecan scab, the most widely distributed and destructive disease of pecan nuts, have been developed that are effective and profitable to use in most seasons. In seasons of frequent rains and high humidity during the susceptible period, effective and profitable control is not always possible. Notwithstanding the poor control obtained some years, experiments carried out over a 12-year period showed that the highly susceptible Schley trees when properly sprayed produced on the average 47 pounds of nuts per tree per year, while similar unsprayed trees produced only 12.5 pounds. On a basis of 10 trees per acre this increase in yield has meant a net profit of about $58 per acre per year after deducting the cost of spraying.

Cultivation and fertilization practices greatly affect pecan yields and quality. Long-time cultural and fertilizer experiments have shown that pecan tree growth, yield, and quality of nuts produced are greatly affected by these practices. Highest yields have been obtained by growing a winter legume cover crop annually that is turned under in early spring and then cultivated to keep down grass and weeds. As a rule fertilizer supplying from 40 to 60 pounds of phosphoric acid and from 50 to 60 pounds of potash per acre applied before or at the time of seeding the winter legume cover crop is required for best production of green-manure. When the cover crop breaks down, the phosphorus and potassium are released and are readily taken up by the pecan roots. It has been found that for most satisfactory production of nuts pecan leaves should have a nitrogen content in September of about 2.4 to 2.6 percent. Higher nitrogen content results in even greater yield but the nuts are less well filled. Lower nitrogen results in lower yields but in better filled nuts.

Chinese chestnut now gives promise of replacing native and European species for the production of nuts. Introduction of Chinese chestnut seed from China by the Division of Forest Pathology of the Bureau has furnished the material for the development of new varieties by breeding which now give promise of replacing the native and European species for the production of nuts for home use and commercial market. The Chinese species has been found to be highly resistant to the chestnut blight disease that destroyed the trees of the native and European species in this country. New varieties of the Chinese chestnut have been developed that come into bearing early and produce annually large crops of nuts having large size and good quality. Trees of these new varieties, Kuling, Meiling, and Nanking are now being planted extensively in home and commercial orchards.

New production practices increase yields of filberts. All filbert varieties have been found to be self-unfruitful and must therefore be cross-pollinated to set large crops of nuts. The various varieties flower at different times and pollen is generally shed before or after the period of pistillate flower receptivity; hence, the problem of providing suitable pollination for commercial varieties is quite involved. Research work has furnished the information whereby it is now possible to insure adequate pollination as to the varieties, number, and arrangement of trees that must be planted together. This work has resulted in greatly increased yields and in the uniformity of the crop from year to year.

Losses of young filbert trees of as much as 25 percent were experienced by growers because of the disease known as filbert blight or bacteriosis. Highly effective and low cost control measures have been

LIBRARY
UNIVERSITY OF ILLINOIS

developed, which when properly carried out will completely prevent all losses.

Filbert trees in Oregon have been found to respons to applications of nitrogen fertilizers with increased yields of nuts. Experiments have shown that $1 invested in ammonium sulphate or ammonium nitrate applied to filbert trees has given a profit of more than $3. The main effects from applications of complete fertilizers has been from the nitrogen it supplied. These findings have resulted in the universal application of nitrogen to filbert trees. Old trees that have gone out of production have been rejuvenated and brought back into heavy production by moderately severe pruning and the application of nitrogen fertilizers.

F. Some Additional Work Needed

Development and evaluation of new nut varieties especially of interspecies hybrids. Practically all nut breeding work done to date has been within the pure species and hence with marked limitations as to the possibility of developing outstanding varieties that would combine the best and most desirable characters of two or more species. For example, if the heavy production of the Persian (English) walnut, its bearing habit, character of nuts, and high resistance to the anthracnose disease could be combined with the hardiness of tree and the flavor and quality of the eastern black walnut, a completely new and outstanding variety would be produced.

New scab-resistant pecan varieties are urgently needed. A new early maturing Persian (English) walnut variety to replace the highly important Franquette is needed now to meet marketing demands.

More new almond varieties to fill special manufacturing requirements are demanded by the candy and other industries. Nut tree breeding is very slow and is a field of work that as yet has been almost untouched. The long-time possibilities of creating new outstanding varieties is very great.

Methods of preventing shriveling or increasing the degree of filling of the nuts. The problem of shriveling or lack of proper kernel development in walnuts, filberts, and pecans has become critical. Trees that produce shriveled or poorly filled nuts one year generally fail to bear a satisfactory crop the following year. As these conditions are most evident in old orchards it is believed that a major part of the trouble is caused by mineral exhaustion of the soil, particularly the so-called minor elements, by unbalanced nutrition resulting from inadequate supply of phosphorus and potassium in relation to calcium and magnesium supply, or by a combination of these nutritional conditions. The solution will require many carefully planned long-time field experiments and a large number of chemical determinations.

Cultural, fertilization, harvesting, and handling practices for Chinese chestnut production. Now that extensive plantings of Chinese chestnuts are being made, research work is needed to determine the soil types, cultural, fertilizer, harvesting, and handling practices that result in best tree growth, yeild of nuts, and market quality. This is a new nut industry.

Additional disease control research needed. Diseases that limit nut production and even destroy the trees have seemingly increased faster than it has been possible to work out satisfactory methods of control. For example the pecan scab fungus, like that causing wheat rust, produces new strains that attack varieties thought to be highly resistant or immune. A disease of Persian walnut, known as "black-line" and apparently a failure of the graft union, is resulting in very severe losses of mature bearing trees in California and the Pacific Northwest. Virus diseases attacking at least four species of walnut, the pecan, and the water hickory are known; these throw the affected trees out of production and ultimately kill them. At present little is known about these diseases.

The development of new types of equipment, materials, and formulations for the control of diseases attacking nut trees or the nuts, or both, are badly needed.

NUT INSECT INVESTIGATIONS

(BEPQ - No. I-b-6 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to develop practical methods for the control of the numerous serious insect pests attacking the various nut crops, and to improve the methods now employed. Current work is directed primarily against the more important insects that attack pecans, secondarily to insects on filberts and chestnuts. Biological studies are made to determine the points in the life cycle of the insect at which it can be most effectively attacked, and when the control measures may be best applied.

B. Currently Active Line Projects

I-b-6-1 - Studies of the biology of the hickory shuckworm on pecan. To provide biological information essential for the development of practical control measures, especially as to the best timing of spray applications.

I-b-6-2 - Control of hickory shuckworm on pecan by cultural methods. To explore the possibilities in the use of a cultural program for control of the hickory shuckworm, and to determine the influence of weather conditions, soil texture, and soil management practices on the effectiveness and expediency of the method.

I-b-6-3 - Control of the hickory shuckworm on pecan by the use of insecticides. To develop a practical insecticide for control of the hickory shuckworm attacking pecan to reduce the serious crop losses now caused by this insect. No effective insecticide is now known.

I-b-6-4 - Control of the pecan nut casebearer. To develop a more effective and practical method for the control of the pecan nut casebearer, with special reference to new insecticides.

I-b-6-5 - Timing of pecan nut casebearer sprays. To develop a more effective, simpler method of timing pecan nut casebearer sprays.

I-b-6-6 - Studies of biology of the pecan weevil. To provide information essential for the effective timing of spray applications for the control of the pecan weevil.

I-b-6-7 - Control of the pecan weevil. To develop effective, practical methods for the control of the pecan weevil, with special emphasis on new insecticides.

I-b-6-8 - Biology of the shoot curculios attacking pecan. To determine the phases of their life histories at which these insects may be most effectively attacked.

I-b-6-9 - Control of the shoot curculios attacking pecan. To develop effective, practical control measures for the control of the shoot curculios attacking pecan.

I-b-6-10 - Control of the pecan aphids. To develop more effective control measures for the control of the pecan aphids, particularly the black pecan aphid.

I-b-6-11 - Investigations of methods of applying insecticides for the control of pecan insects. To develop more effective means of applying insecticides for control of pecan insects, including the development of suitable formulations for use in different types of equipment.

I-b-6-12 - Investigations of miscellaneous pecan insects. To develop practical control measures for the control of miscellaneous pecan insects, and to make observations on habits and seasonal history on such insects to determine the stages at which control measures may best be applied, and to aid in the timing of spray applications.

I-b-6-13 - Control of the filbert worm with insecticides. The development of more effective, practical methods of controlling the filbert worm with insecticides.

I-b-6-14 - Studies of biology of the chestnut weevils. To provide information on the seasonal occurrence and life history and habits of the chestnut weevils as a basis for the timing of spray applications.

I-b-6-15 - Control of the chestnut weevils. To develop effective practical insecticides for the control of the chestnut weevils.

C. History and Evolution of This Work

Investigations of insects affecting tree nuts, including pecans, walnuts, filberts, chestnuts, and hickories, were started in a small way in the early 1900's, but had their real beginning in 1913, when field headquarters were established for work on pecans. Studies of pecan insects have continued since that time because of the expansion of the pecan industry and serious losses due to insects. Work on filberts, incidental to other studies in the early days of the project, has been continuous since 1937 as the industry expanded in the Pacific Northwest. Studies on insect pests of other tree nuts have been conducted intermittently to meet specific problems. Early studies were concerned largely with identifying the insects causing injury and with obtaining information on their life histories and habits as a basis for developing control measures. At first, considerable attention was given to natural enemies and cultural control practices. Progress has been made in developing effective, practical control measures for an increasing number of the many serious pests of tree nuts as new methods of using old insecticides have been found, or as new, more potent materials have become available.

D. Funds--Annual Expenditures

It is estimated that expenditures for the study of insect pests of tree nuts ranged from $200 to about $1000 per year from 1900 to 1913. Expenditures for this work fluctuated slightly from year to year from 1913 to 1927 but gradually increased from $2200 to about $15,000. They were further increased, particularly in 1928, 1929 and 1931, when work on pecan insects was greatly expanded, until they reached a peak of about $38,000 in 1932, and then dropped to about $16,000 in 1934. Funds have since increased gradually as costs have risen, to range from about $20,000 in 1936 to about $38,000 in 1949 and about $40,000 in 1950.

E. Examples of Outstanding Accomplishments

Control of nut insects based on knowledge of identity, life history and habits. The identification, description and biological studies of insects affecting tree nuts, on which most present day work in this field is based, may be credited in a large measure to Department activities in the early years of this project. As a result of the completeness of these studies and their accuracy, only limited biological studies, to account for local and seasonal inconsistencies in habits and development and to time spray applications, are now required for many common insects affecting tree nuts.

Cultural control developed for the hickory shuckworm, a major pest of pecans that cannot yet be controlled by sprays. Knowledge that the development of immature hickory shuckworm larvae in pecan nut drops can be prevented if the nuts are buried under four or more inches of soil led to a recommendation whereby about half the injury caused to pecans by this insect can be prevented by plowing under infested nut drops in July and August with a disk tiller plow.

Spray programs for control of the pecan nut casebearer developed, improved, and widely used by growers. Work with the many natural enemies of this pest revealed that they could not be readily utilized for dependable control and that insecticides must be resorted to. Bureau work aided in the development of the spray program based on lead arsenate for use in the semi-arid areas of the pecan belt and was responsible for the development of the nicotine sulfate-oil program for use in the more humid areas. Recently, DDT has been found to have several advantages over former spray programs and is now coming into wide use. Progress is still being made in this work, particularly with reference to the development of an improved method of timing spray applications.

Pecan weevil well controlled by DDT. This beetle, which destroys both small and maturing pecan nuts and is increasing in importance throughout the pecan belt, resisted all control efforts with insecticides for many years. Recent work has resulted in the recommendation of an effective spray program based on DDT that reduces injured nuts by 90 percent or more. This treatment is rapidly being adopted by pecan growers throughout the pecan belt. Indications have been obtained that toxaphene may be about as effective as DDT and less expensive. The most effective method of control prior to DDT was to bump the trees at intervals to jar the beetles onto a sheet from which they could be collected and destroyed. This cut losses due to this insect about in half.

Control measures developed for the pecan phylloxera. This is an insect that causes numerous tumor-like swellings on the leaves, leafstalks, nuts and succulent shoots of pecans. Studies in Louisiana showed that the phylloxera could be controlled effectively with nicotine sulfate in combination with liquid lime sulfur on mineral oil emulsions. Such treatments have been in general use for a number of years wherever this increasingly important insect has been a problem. Recent revival of work on the pecan phylloxera has indicated that some of the new dinitro and benzene hexachloride sprays may control it effectively.

Chestnut weevils controlled with DDT. These weevils have long been a serious limiting factor to the successful revival of a chestnut industry based on blight-resistant varieties because they could not be controlled satisfactorily with the recommended lead arsenate spray program. The recent finding that DDT will give a high degree of control of these weevils may well result in reviving interest in commercial plantings of chestnuts. Work is in progress to determine the best time to apply DDT and to determine the value of other newer and potent organic insecticides.

F. Some Additional Work Needed

Control measures needed for the hickory shuckworm on pecans. This insect causes a continuing loss of nuts throughout the growing season everywhere in the pecan belt and reduces the quality of many nuts that reach the harvest period. A more widely applicable and effective method than burying infested drops by cultivation is urgently needed. Intensive studies of new insecticides and schedules for their application are under way in the hope of developing an effective spray program.

Work needed on insecticides other than DDT. The widespread adoption of DDT by pecan growers has often been followed by outbreaks of other pests. Mites and aphids particularly have required additional control efforts. This means that work should be continued with other new, potent organic insecticides against such pests as the pecan nut casebearer, pecan weevil and chestnut weevils to find a material that will give control alone or in combination with DDT without allowing additional pests to increase to damaging proportions.

Further experiments needed with insecticides for filbert worm control. The present recommended treatment for the filbert worm, based on lead arsenate, is not fully satisfactory, particularly against moderate or heavier infestations in older orchards. A high degree of control is important from the standpoint of grading and packing as well as preventing crop losses. New insecticide materials should continue to be evaluated as rapidly as they become available.

Better equipment needed for applying insecticides to nut trees. Nut trees, particularly pecans and walnuts, frequently attain such large size that it is not unusual for a recommended treatment to fail to give satisfactory control because of incomplete spray coverage. This is especially true in the control of the black pecan aphid, an insect that often causes such severe premature defoliation of pecans that affected trees fail to produce a crop the following season. Work is urgently needed to develop more efficient types of spray equipment for treating large-sized trees thoroughly and to develop suitable formulations of insecticides for use with them.

FRUIT PRODUCTION AND IMPROVEMENT FOR COLD AND DROUGHT RESISTANCE IN THE GREAT PLAINS

(BPISAE - b-1-5 - Federal--Regular Funds)

A. Purpose and Nature of Current Work

To obtain through variety tests, cultural studies, and plant breeding, varieties of fruits of high quality and productivity suitable for home gardens and commercial culture under the extreme environmental conditions of the Great Plains Region. Varieties and species of fruit from cold areas throughout the world are assembled so far as practicable at testing locations and evaluated for their usefulness for production under Plains conditions and for use in breeding work. Most promising varieties and selections from breeding work are widely tested throughout the areas in cooperation with State and other Federal agencies and with farmers.

B. Currently Active Line Projects

b-1-5-1 - Breeding and adaptation tests with small fruits, to find or develop types of grapes, strawberries, raspberries, and other berries adapted to Central Great Plains conditions. To breed varieties of strawberries and raspberries adapted to the severe climate of the Central Great Plains region that will increase the income of farmers, fruit growers, and nurserymen of the region and that will improve the diet of the people. No variety of raspberry or everbearing strawberry has been found that is reliably winter hardy throughout the region.

b-1-5-2 - Testing and evaluation of important tree and bush fruits. To find varieties of tree and bush fruits adapted to the cold, dry, windy climate of the Central Great Plains, in order to improve the diet and increase the income of farm and ranch families of the region.

b-1-5-4 - Vitamin content of native fruits and adapted varieties. To select kinds and varieties of fruits with high vitamin content to maintain and improve the nutrition of the people of the Great Plains.

b-1-5-5 - Variety testing of fruits for the Northern Great Plains region. To determine the hardiness, productiveness, and quality of fruit for both standard varieties and new introductions and to obtain information as to their usefulness for planting in the Northern Great Plains. Variety tests include apples, crabapples, plums and plum hybrids, pears, apricots, cherries, sandcherries, grapes, raspberries, strawberries, currants, gooseberries, juneberries, and other hardy fruits.

b-1-5-6 - Fruit breeding for the Northern Great Plains region. To develop new varieties of fruits better adapted to conditions in the Northern Great Plains.

b-1-5-7 - Cultural methods tests with fruits in the Northern Great Plains region. To determine best cultural practices for growing fruits in this region.

b-1-5-8 - Pruning methods for the Northern Great Plains region. To determine pruning methods that give best results for fruit trees planted in the Northern Great Plains.

b-1-5-9 - Performance of dry land orchards in different sites and localities in the Northern Great Plains region. To determine the effects of different sites on the success of orchard plantings; to test varieties over a wide area of the Northern Great Plains.

b-1-5-10 - Variety testing of fruits for the Southern Great Plains region. To determine what varieties of tree fruits, grapes, and nuts will produce reliably under the severe climatic conditions of this area.

b-1-5-11 - Fruit breeding for the Southern Great Plains region. To originate fruits, especially grapes, better adapted to the conditions of this area than varieties now available.

b-1-5-12 - Chlorosis treatment for fruits in the Southern Great Plains region. To find methods of growing grapes on the alkaline soils common in this area.

b-1-5-14 - The effect of soil, site, and climate on survival and growth of fruits in the farmstead plantings in the Southern Great Plains region. Information obtained from cooperative farm plantings made by the owners.

C. History and Evolution of This Work

Work under this general project was started about 1916 at the Dry Land Investigation Field Stations at Mandan, N. D. (Northern Great Plains), and Woodward, Okla. (Southern Great Plains). In 1929 investigations for the Central Great Plains were started at the Horticultural Field Station at Cheyenne, Wyo. In 1946 the work for all three areas was consolidated into the present work project. During World War II much of the work was suspended or placed on a bare maintenance basis.

D. Funds -- Annual Expenditures

From 1935 to 1945 funds for the fruit investigations at Cheyenne averaged about $12,500 per annum. After merger of the work at the three stations the total for all was about $34,000 in 1946 and 1947, $26,680 in 1948, $28,450 in 1949, and $29,530 in 1950. Before the merger, the expenditure for this work at Mandan and Woodward was about $6,000 annually at each place.

E. Examples of Outstanding Accomplishments

Promising selections of new types of grapes, raspberries, strawberries, currents, gooseberries, plums, apricots, peaches, apples, crabapples, and cherries have been obtained in the various breeding programs, and have been propagated for further testing with a view to introduction.

Recommendations of adapted fruits for each section have been available to guide farmers in their selection of planting material for home and commercial purposes.

Four varieties of extremely winter-hardy, June-bearing strawberries have been originated and released for production. They are widely grown in the Central Great Plains and are proving satisfactory. Early Cheyenne 1 is the earliest of these. It produces small, soft, aromatic berries but is fully winter hardy in the Central Plains. Cheyenne 2 is ten days later than Early Cheyenne 1, larger with excellent flavor and completely winter-hardy in the High Plains. Cheyenne 3 is ten days later than Cheyenne 2, high-flavored, and though hardier than common varieties, it is not so hardy as the above two. Sioux is medium sized, high flavored and hardy in Wyoming and Nebraska.

Large collections of various kinds of hardy fruits have been brought together from all parts of the world, their adaptation and general usefulness determined, and the most promising ones further tested under farm conditions in the various regions of the Great Plains.

Methods of fruit culture suitable for use under conditions in the Great Plains have been developed and the information made available to growers.

F. Some Additional Work Needed

Extensive testing of new selections from breeding work, by cooperators on farms and at experiment stations in the region.

Tests of 49 collections of wild raspberries for winter hardiness, and of varieties that bear on current-year wood for earliness and other desirable characters. The most promising will be used in further hybridizing.

Winter-hardy strawberry varieties needed. Though four relatively winter-hardy strawberry varieties have been introduced that enable gardeners to produce this fruit through a part of the Great Plains area, not heretofore possible, the four varieties are relatively small, soft and unproductive as compared with the best commercial varieties and are restricted in their adaptation. Varieties should be bred for Eastern States to eliminate the cost and need for mulching for winter protection.

Propagation and testing of Nanking cherry selections and of the superior red currant selections.

QUALITY EVALUATION OF FRUITS
(BPISAE b-1-7 - Federal-State--Regular Funds)

A. Purpose and Nature of Current Work

To determine (1) the relative merits or lack of merit of the numerous commercial varieties and of certain breeding lines of different fruit crops for processing by different methods, and (2) the variations in vitamin content of fruits in relation to variety, stage of maturity, storage methods of handling, method of processing, light intensity and duration, temperature, and other factors. Current emphasis is on evaluation tests.

B. Currently Active Line Projects

b-1-7-1 - Vitamin content of fruit varieties and strains to determine nutritional value. To test vitamin content of different varieties and of selections from breeding work.

b-1-7-2 - Evaluation of fruit varieties for processing, especially for freezing and canning. To test the different varieties and selections from breeding for their value for freezing and canning and to determine the best methods and time for freezing and canning.

C. History and Evolution of This Work

The vitamin studies were formally started in 1943 and so far surveys have been made of the vitamin content of varieties of apple, peach, strawberry, and blueberry. Such surveys have given our research workers a basis of evaluating different varieties for use in breeding work and to determine whether breeding work would be useful for high vitamin C content. Though extensive work on evaluation of fruit for processing has been carried on through the years, in particular on strawberries, grapes, peaches, and apples, systematic work on evaluation of fruits was reestablished in 1947, beginning with a survey of the usefulness of apple varieties for freezing.

D. Funds -- Annual Expenditures

The annual expenditures for this work and the vitamin work on vegetables have been between $13,890 in 1945 and $14,970 for 1950, that for fruits is estimated to average $1,000 per year.

E. Examples of Outstanding Accomplishments

Vitamin content of strawberries. It has been found that the vitamin C content of the strawberry averages about 60 units per 100 milligrams for the country as a whole and that some varieties or selections may have twice this amount and some only about half as much. Because of this high vitamin content, strawberries can now be recommended as one of the sources of vitamin C for general use and for specific use by physicians and hospitals. Some studies have been made of the effect of shade and temperature on vitamin C content.

Evaluation of apple varieties for freezing during the post-harvest period. A preliminary survey of the value of the leading apple varieties (19 varieties) which make up 90 percent of the crop of the United States, was begun in 1947. Flavor, susceptibility to discoloration, and susceptibility to mushing of each variety after freezing have been followed over the entire storage life of each variety. All varieties require some degree of corrective treatment to control discoloration and disintegration at some stage of their storage life. This study determined the extent of that need. This was followed by a study of antioxidents and firming agents in a wide range of concentrations over the storage life of each variety. The amount and method of application to give optimum preservation of color and flavor have been determined.

F. Some Additional Work Needed

Testing breeding material for high vitamin C content of strawberry. Because fully twice the vitamin content of the average has been found in some selections it has seemed desirable to start breeding for high vitamin C content of the strawberry, a fruit which can be grown throughout the entire United States and which will furnish a fresh source of this essential food material early in the summer season as well as in a processed condition throughout the year. Analyses of seedlings and selections need to be made to determine the mode of inheritance of this quality to assist breeders in this work.

Vitamin content of blueberry. Some analyses of the vitamin content of this fruit have been made. The analyses indicate that blueberries have about the vitamin C content of tomatoes. However, analyses of some samples from New Jersey in 1949 showed only traces of vitamin C. Surveys of species, varieties, and selections as well as conditions affecting vitamin C should be made to complete this work.

Conditions affecting vitamin C content. It has been proved that the vitamin C content of the strawberry is affected by shade. However, the content of the same variety under different conditions has shown differences of as much as 100 percent. Additional work on the effect of temperature and the quality, duration, and intensity of light is needed to determine further the conditions affecting vitamin C.

Studies of the effects of the varying climatic conditions in different regions where the varieties are grown on their processing qualities. It is known that a variety highly suitable for canning or freezing in one region may not be as suitable in another. A survey of the reasons for this as it affects the leading varieties is needed.

Studies of the value of new varieties and selections for processing. Studies on present varieties show great differences in their processing value at different stages of ripening after harvest. Because of this, new varieties need to be tested to determine their usefulness and the best stage of ripening for processing.

INVESTIGATIONS OF INSECTS AND VIRUS DISEASES OF PEACH
(BEPQ - No. I-b-5 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to determine the species of insects that may be responsible for the transmission of peach mosaic, a destructive virus disease of peach in the southwestern States, and additional insects that may be involved in the transmission of phony peach, a virus disease responsible for the loss of thousands of peach trees each year in the southeastern States. Current work relates to (1) the development of information on the biology and habits of the leafhoppers that carry the phony peach virus, (2) the determination of the incubation period of the virus in the leafhoppers, (3) the duration of their ability to transmit the disease after they have become infective, and (4) the development of other essential information on virus transmission. This information is basic to the development of measures for controlling the leafhoppers that will augment the present method of preventing spread of phony peach by destroying all trees that develop symptoms of the disease.

B. Currently Active Line Projects

I-b-5-1 - Survey of insects in and near peach orchards in areas where phony peach, peach mosaic, and other stone-fruit viruses occur. To provide information on the insects most likely to transmit phony peach, peach mosaic, and other stone-fruit virus diseases, as a basis for insect transmission studies, and to provide essential information on the host relationships, seasonal habits, and to study the distribution of the leafhopper carriers of phony peach virus.

I-b-5-2 - Transmission studies with insects suspected of being vectors of phony peach disease. To carry on experiments to determine whether insects other than those already incriminated may also be partially responsible for natural spread of phony peach virus disease, as a basis for the development of fully effective practical methods of preventing natural spread.

I-b-5-3 - Transmission studies with insects suspected of being vectors of the peach mosaic virus. To determine the insects responsible for the transmission of peach mosaic virus as a basis for the development of methods of preventing natural spread of this disease.

I-b-5-5 - Field studies to determine the time of year natural spread of phony peach disease occurs as a basis for more effective application of control measures.

I-b-5-6 - Field studies to determine the time of year natural spread of peach mosaic disease occurs, as a basis for more effective application of control measures.

I-b-5-7 - Field tests of insecticides as a method of preventing or limiting natural spread of phony peach virus disease. To explore the possibilities of retarding or limiting the natural spread of phony peach disease through the use of insecticides that are effective against the leafhoppers which are responsible for natural spread and against other insects that may be involved.

I-b-5-8 -- Field tests of insecticides as a method of preventing or limiting natural spread of peach mosaic. To explore the possibilities of retarding or limiting the natural spread of peach mosaic disease through the use of insecticides that are generally effective against types of insects suspected of being responsible for natural spread.

C. History and Evolution of This Work

Phony peach is an exceedlingly serious virus disease of peach which was first observed in Georgia more than 50 years ago. By 1929 it had taken a toll of over a million peach trees, and occurred from Texas and Arkansa to Georgia and the Carolinas. The Department of Agriculture, in cooperation with the States involved, started a diseased tree removal program in 1929. This program apparently eradicated phony peach in some areas and controlled it exceedingly well in others. In areas of rapid spread in Alabama and Georgia, however, thousands of peach trees continue to contract the disease each year. It became increasingly evident that the yearly tree losses might never be appreciably reduced until the insect carriers were discovered and controlled. Studies to determine the insect carriers of phony peach and develop control measures for them were started in the southeastern States in 1936. These have been pursued by Department entomologists continually since that time. With the identification in 1948 of 4 species of leafhoppers as carriers of phony peach disease, work on the life histories of these species and the development of control measures for them has been started.

Peach mosaic, another destructive virus disease, was first found in Texas and Colorado in 1931. By 1935, it had become a serious problem in several of the southwestern States. At the present time, it is responsible for the loss of several thousands of peach trees each year even though it is the object of an intensive control program. Studies to determine the insect carriers of peach mosaic virus have been carried on in California since 1937. Supplementary work was conducted at a substation in Texas for a few years prior to the beginning of World War I

D. Funds--Annual Expenditures

The amount expended in 1936, when work on the phony peach insect carriers was started, was approximately $8,000. From 1937 to 1949 annual expenditures have ranged from about $16,000 to $23,000 with an average of approximately $20,000. The allocation for 1950 was about $29,000. The expenditures are about equally divided between the phony peach and peach mosaic projects.

E. Examples of Outstanding Accomplishments

Leafhopper carriers of phony peach virus discovered. After more than a thousand transmission experiments with a variety of insects suspected of being carriers of the virus, definite proof was obtained in 1948 that four species of leafhoppers are able to spread phony peach. This discovery has great significance because it offers a new approach to the control of phony peach. If investigations now under way to develop methods for destroying the leafhopper carriers are successful, the staggering tree losses sustained by many peach growers each year may be eliminated or greatly reduced. A knowledge of the carriers, their habits, and host relationships may also benefit peach growers in areas where phony peach does not occur by permitting greater effectiveness in the application of regulatory procedures to prevent the further spread of the disease.

Time of year natural spread of peach mosaic occurs determined. It was found in experiments conducted by entomologists and plant pathologists that peach mosaic spreads throughout the growing season but mostly during a period in the spring. This knowledge is important to the peach mosaic control program, and may result in a more effective application of inspection and tree removal control procedures, with subsequent benefits to the growers.

Insect surveys in peach orchards led to solution of phony peach problem. Insect surveys were made in many peach orchards in the western and southern parts of the United States to provide a basis for insect transmission studies. Hundreds of species were collected and classified. The information gained through this survey led directly to the solution of the phony peach insect carrier problem, and contributed to the discovery of an insect carrier of another destructive virus affecting peach in the Pacific Northwest. The latter disease will be reported under another project.

F. Some Additional Work Needed.

Studies needed to develop adequate information on the life history, habits, and host relationships of the leafhopper carriers of phony peach virus. There is available relatively little biological information on the four leafhopper carriers of phony peach. Biological information is essential as a basis for the development of effective control measures for these leafhoppers that may be used in official control programs or by commercial growers.

Need for virus-free leafhoppers for experimental purposes and for additional information on the factors which affect phony peach transmission. The leafhopper carriers of phony peach have been found difficul to rear with ordinary methods, and adequate numbers cannot be collected in nature. Virus-free leafhoppers are needed for experiments to determi the incubation periods of the virus in the leafhoppers, how long a leafhopper is able to transmit phony peach after acquiring the virus, additional hosts of phony peach, and other factors which may have a bearing on phony peach transmission.

Investigations needed to determine methods for controlling the leafhopper carriers of phony peach. Available insecticides should be evaluated for leafhopper control in the laboratory and in large-scale field tests to determine if practical control of the disease can be accomplished by reducing the numbers of insect carriers.

More studies necessary to determine insects that spread peach mosaic. Although more than 6,000 transmission tests with many different kinds of insects have been made, the manner in which peach mosaic spreads remains a perplexing problem. Since the need to find the insect carriers of peac mosaic is as urgent as ever, this activity should be continued in all the regions where it is important.

INTRODUCTION AND EVALUATION OF FRUIT AND VEGETABLE CROPS
(BPISAE - b-11-1 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

To bring into the United States, its territories and possessions fruit and vegetable seeds and other plant material for evaluation either as new crops or for use in breeding programs to increase quality, productiveness and resistance to disease. This work involves the international exchange of living plant material with all parts of the world and direct exploration in foreign areas when our needs can not be obtained through correspondence; the sanitary precautions and propagation in quarantine of foreign plant materials to insure the prevention of introducing new diseases; the preliminary evaluation of introduced material to ascertain its potential value as a new crop or for current breeding programs; its placement with plant investigators best able to utilize its potentialities, and the maintenance of valuable breeding stocks for future plant programs. This project is closely related to Projects b-11-2 and b-11-3, the three projects covering plant introduction work for all crop categories under investigation in the Department of Agriculture and State Experiment Stations.

B. Currently Active Line Projects

b-11-1-1. Foreign placement of experimental stocks of fruits and vegetables. To supply foreign agricultural experiment stations with experimental quantities of budwood and seed of fruits and vegetables from germ-plasm collections in the United States. This covers a phase of plant introduction which brings to us valuable stocks in international exchange.

b-11-1-2. The introduction, sanitary inspection, and inventory of fruit and vegetable crops. To introduce living material of fruits and vegetables and their wild relatives from all parts of the world by exploration, exchange or purchase; to process all introductions through sanitary inspection and quarantine if necessary; and keep permanent inventory records.

b-11-1-3. Preliminary evaluation, maintenance and domestic placement of fruits and vegetables. To test fruits and vegetables so as to determine their potentialities either directly as crops or as parents for breeding programs; to maintain the valuable kinds in collections for future use; and to make available to experiment stations, institutions and nurseries selected introductions for further test or distribution to the public. This line project covers all material not currently receiving special handling under work project.

b-11-1-4. Introduction, evaluation, and placement of hardy apple interstocks. To introduce and search for the hardiest of apple varieties for use as main tree axes for orchards in the coldest parts of the United States where injury to trunks is serious.

b-11-1-5. Introduction, evaluation, and development of cider apples for the United States. To introduce and evaluate for astringency European cider varieties for breeding stock to produce domestic varieties especially adapted for apple juice and cider.

b-11-1-6. Introduction, evaluation, and placement of Mazzard and Mahaleb cherry rootstocks. To introduce and test variations of these two ~~varieties~~ species commonly used as rootstocks in the hope of finding types which breed true and are more vigorous, as well as more resistant to leaf-spot disease, than those now being used by commercial growers.

b-11-1-7. Introduction, preliminary evaluation and development of the pistachio nut. To introduce species and varieties of pistachio nut to determine the best strains for use as rootstocks, pollenizers, ornamentals and nut producers in an attempt to establish this nut crop in northern California and adjacent areas.

C. History and Evolution of This Work

The introduction of plant materials from foreign countries was probably one of the first agricultural activities of the federal government. As early as 1819 a circular from the Secretary of the Treasury went to all representatives of the consular service, urging the sending home of important plant materials discovered in foreign countries. In 1839 an appropriation of one thousand dollars was granted by Congress initiating work on the collection and dissemination of agricultural seeds and plants then carried out by the Commissioner of Patents. Much that was introduced in those early days received inadequate trials in areas poorly adapted to their development. In order to go about the intelligent introduction of foreign plant materials and give them appropriate tests, a unit was established in the Department of Agriculture in 1898, which marks the beginning of this work project. In 1904, plant introduction gardens were first established to test the materials brought in. Although seven of these were once in operation, four such federal stations remain today in California, Florida, Georgia and Maryland where at any one time may be found about 25,000 introductions under test and propagation. For many years material was widely distributed to cooperators under an Experimenter's Service, the introductions furnished gratis and reports expected on their behavior. It was found that private growers contributed very little, either in the way of reports or in the establishment of new materials, and the list in later years was greatly curtailed, coming to a complete stop in World War II. The placement of new introductions is now carried out with experiment stations, a few responsible nurserymen and specialists from whom reports on test may reasonably be expected. Since 1898, about 190,000 introductions have been brought in of all types of crop material and of these about 75,000 were fruits and vegetables. Although entirely new potential crops are now rarely discovered, the need for breeding material to keep our stocks increasingly healthy and productive remains great.

D. Funds - Annual Expenditures

Except for certain years when foreign explorations caused abnormal expense, the history of appropriations for this work shows a gradual increment reflecting higher costs of operations and increased demands for material as agricultural research has developed. In 1898, funds available were about $8,000. From 1898 to 1920 the costs had increased to about $40,000. By 1930 the annual cost reached a high of $90,000, and since then has gradually leveled off to approximately $60,000 per year at the present time.

E. Examples of Outstanding Accomplishments

Introduction and establishment of date industry in the United States. Scattered plantings of date palms were known since early Spanish colonial days in southern California, but the coastal climate and inferior seedlings caused little interest until about 1850 when seedlings were planted in the hot interior valleys of California and Arizona. In 1900 and the years immediately following, exploration for dates was made in Algeria, Tunisia, Egypt, and Mesopotamia which yielded the select varieties commercially grown today in California and Arizona. This slow-growing crop has nowhere near reached its developmental peak. In 1929 its farm value was $193,000; in 1948 this value had jumped to $1,839,000. Over half the acreage planted in Arizona is not yet bearing. Production of dates in the United States in 1944 was 18,000,000 pounds, and during that same period we imported 50,000,000 pounds, which indicates possibilities for crop development based on demand.

Introduction and development of the blueberry industry. The blueberry is one of the few fruit crops we grow which originated from plants growing wild in the United States. The exploration in the eastern United States for good wild types and the preliminary testing and early breeding work necessary to develop this wild plant into a domesticated crop was done under funds of this project. A conservative figure on the cost of the preliminary introduction and testing phases of blueberry work is $153,000. This may be compared with the $2,000,000 estimated value of the crop in 1944.

Plant introductions are basis of avocado industry. Avocados were known as dooryard trees in Florida and California since early colonization by Spaniards, who brought them from tropical America where they are native. As people acquired a taste for avocados, plantings were increased and fruit imported. In 1905 no domestic fruit reached the market, but there was considerable interest in the potentialities of the crop for Florida and California. Intensive exploration for outstanding types of avocados was carried out in the West Indies, the northern Andes of South America, and in the mountains of Central America. Selections made from these introductions are now the basis of our commercial industry. By 1929, the farm value of the avocado crop was $323,000; in 1940, it was worth $1,648,000; and in 1948, the value had increased to $5,563,000. The total cost of exploration and testing can be estimated at $120,000.

New rootstock for English walnuts found in Asia. The English walnut is a 24 million dollar crop in California and any improvement, however small in its condition of growth and production, will give a considerable annual dividend. The native western black walnut has been the customary rootstock upon which all English walnuts are grafted. This rootstock is subject to eel-worm damage and has other growth drawbacks which have given the growers considerable dissatisfaction. After ten years of test at the Chico, California, introduction garden, a new Asiatic walnut relative has shown itself more resistant to eel-worm damage as well as being a more vigorous rootstock for English walnuts.

Thrip-resistant wild onion from Persia helps Texas onion industry. Losses to the onion industry have been heavy in Texas, due to depradations of the insect called Onion Thrip which crawls and increases between the loose scales where bulb and stem meet causing severe damage. A wild onion with very tight scales, introduced from Persia, solved this problem when used as a parent in breeding with our commercial onion varieties.

Other miscellaneous accomplishments. Resistance to the stem-rot dis ease of sweet potatoes was found in a sweet-potato introduction from Tinian Island in the Pacific. Resistance to spinach-blight, which hit the development of that crop in its infancy, was found in a wild spinach from Manchuria. A wild cantaloupe, picked up by a plant explorer in India, when used as a parent in breeding, saved the melon industry in California in the 1930's badly hit by the Downy Mildew disease. Resistance to Anthracnose disease came with a watermelon introduction from southern Africa. The new variety "Congo," released in the southeastern United States, is a development from this introduction. These and numerous other introductions of fruits and vegetables have made it possible for breeders to develop new varieties worth many millions of dollars to the growers of the United States.

F. Some Additional Work Needed

Lettuce. A disease called Lettuce Yellows has badly crippled the lettuce-growing industry in the Northeastern States, one of the three large areas of lettuce production. Wild lettuce relatives from all parts of the world are being introduced and examined for resistance to this disease. So far, resistance has been found but in types which will not cross with our cultivated strains. The search needs to be continued until a usable source of resistance or a remedy is found.

Beans and Peas. When one notes the very high annual production of these two leguminous crops in the United States, the finding of resistance to their worst diseases becomes a problem of serious significance. In 1947 green lima beans alone were worth three million dollars, snap beans twenty-four million, soybeans six hundred and twelve million, and green peas forty-seven million. Success already obtained through plant introduction programs indicates that there is need for a concentrated effort to tap the world centers of variability in the Near East and Ethiopia to bring in the valuable material that may exist there.

Apples. Greater cold hardiness to withstand the winters of the Northern Great Plains and northern New England is needed. One phase of this problem is currently receiving attention under b-11-1-4 by use of cold-resistant interstocks. Search for low dormancy requirements is also being made in an attempt to extend southward in the United States successful apple culture.

Peaches. Introductions from Asia indicate the possibility of obtaining peach root stocks with resistance to eel-worm for those areas badly infested with this dis ease. This work should be expanded. Late-blooming types to lower the danger of fruit destruction from early frosts is another problem of great importance that might be partially solved by the plant introductions from foreign sources.

Cherries. The search for a more vigorous and disease-resistant stock among the Mazzard and Mahaleb varieties needs to be continued.

Citrus. Citrus relatives are being introduced in search for a rootstock as good as sour orange to replace this variety which, when used with sweet orange, is susceptible to the very serious Tristeza disease now seriously ravaging citrus groves in South America. This is an attempt to forestall this disease should it invade our domestic groves and should be continued until all world varieties or types have been introduced and tested.

Mangoes. Many delicious tropical fruits that could be grown in the warmer parts of the United States are unknown in our markets because of the difficulties of quick transportation. Air transport has considerably changed this situation. Mangoes are now being planted in extensive acreage based on material introduced through the years and held at the Coconut Grove, Florida, introduction garden. To implement this development, the hundreds of Asiatic species and varieties should now be brought in to test for sturdy types to resist hurricanes and to increase quality and production.

Lychee. This is another Asiatic fruit now just developing in Florida and California. Current "on-the-tree" prices are one dollar a pound with demand far greater than production. All plantings now being made are of one variety, with many more probably better kinds to be obtained in Asia.

CROSS REFERENCES - PRODUCTION

For additional information especially pertinent to the subjects reported on in this chapter see also.

BEPQ - c-c-1 - Chapter 35, Mexican fruitfly control.
BEPQ - c-g-1 - Chapter 35, phony peach and peach mosaic.
BEPQ - c-g-2 - Chapter 35, phony peach and peach mosaic.
BEPQ - I-a-2 - Chapter 12, fruitfly investigations in Mexico.
BEPQ - I-a-3 - Chapter 12, fruitfly investigations in the Canal Zone.
BEPQ - I-b-10 - Chapter 31, Japanese beetles.
BEPQ - I-e-8 - Chapter 31, white fringed beetle investigations.
BEPQ - I-g-1 - Chapter 38, bee diseases and poisoning.
BEPQ - I-g-2 - Chapter 38, bee management.
BEPQ - I-g-3 - Chapter 38, insect pollination (bees)
BEPQ - I-k-1 - Chapter 31, natural enemies of insect pests and weeds.
BEPQ - I-m-3 - Chapter 31, insecticide residues.
BEPQ - I-n-5 - Chapter 31, effect of insecticides on parasites and predators.
BEPQ - I-o-1 - Chapter 12, Oriental fruitfly biology and ecology.
BEPQ - I-o-2 - Chapter 12, Oriental fruitfly biological control.
BEPQ - I-o-3 - Chapter 12, Oriental fruitfly chemical control.
BEPQ - I-o-4 - Chapter 12, Oriental fruitfly area control.
BEPQ - I-o-5 - Chapter 12, Oriental fruitfly commodity treatments.
BEPQ - I-o-6 - Chapter 12, Oriental fruitfly physiology.
BEPQ - Chapter 14, emergency surveys of insect pests injurious to vegetables and fruit crops, and their control requirements.
BEPQ - Chapter 35, Gpysy and Brown-tail moths control.
BEPQ - Chapter 35, Hall scale control.
BEPQ - Chapter 35, white fringed beetle control.
BEPQ - BAI, BDI, BPISAE, BAIC - RM:b-72 - Chapter 31, toxicological effects of insecticides, fungicides and herbicides on soils, plants and animals.
BEPQ - RM:b-264 - Chapter 12, fruitfly natural enemies importation and establishment.
BPISAE - b-11-1 - Chapter 13, introduction and evaluation of fruits, nuts and vegetables.
BPISAE - b-12-1 - Chapter 31, nematode studies.
BPISAE - c-1-2 - Chapter 21, disease-resistant chestnut trees.
BPISAE - d-2-1 - Chapter 22, fertilizer materials, improvement, etc.
BPISAE - q-2-2 - Chapter 38, plant disease survey.
BPISAE - RM:b-48 - Chapter 31, research on nematodes.
BPISAE - RM:b-57 - Chapter 31, methods and equipment for weed control.
BPISAE - RM:b-68 - Chapter 30, equipment and formulations - insecticides and fungicides.
BPISAE - OES - RM:b-111 - Chapter 38, introduction and testing of new plants, etc.
BPISAE - RM:b-532 - Chapter 38, agricultural chemicals on insect pollination.
OES - b-1-11 - Chapter 31, control insect pests and diseases.

UTILIZATION INVESTIGATIONS ON FRUITS OF THE WESTERN AREA*

(BAIC - RRL-3-11 - Federal-State - Regular Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To effect greater and more efficient utilization of fruits through improvement in quality of present products, and reduction in costs involved in getting the fruit from the producer to the consumer. The work consists of technological and engineering investigations on canning, dehydrating and freezing methods of fruit preservation. Convenience to the user, as well as high initial quality and long shelf life, is given special attention in the development of products. Technological investigations are concerned with all steps involved in fruit preservation, from selection of the raw material to packaging and storage of the finished product. Engineering investigations include development of equipment, pilot plant investigations on processes developed by the Bureau, and analysis of processing and product costs. More profitable and efficient use of fruits is also being sought through utilization of cull fruits and processing wastes (e.g., cores, peels or pits) for making useful industrial chemicals or protein- and vitamin-rich animal feeds. In addition, fundamental physical, chemical and microbiological studies on fruits or their chemical constituents are under way to provide basic information for more rapid and effective solution of existing and future problems.

B. Currently Active Line Projects

RESEARCH PROJECT RRL-3-(11)-FP-1 - CHEMICAL AND PHYSICAL CHANGES IN FRUIT AND FRUIT PRODUCTS DURING PROCESSING AND STORAGE.

RRL-3-(11)-FP-1-1 - The role of moisture in the preservation of fruit products. To obtain fundamental information on moisture in fruit products for the purpose of eliminating the caking of fruit powders, for design of dehydration equipment, for selection of suitable protective packaging materials and for standardization of the products.

RRL-3-(11)-FP-1-2 - Deterioration in fruit and fruit products during processing and storage. To obtain accurate data on the constitution of fruits and to explain the chemical changes that occur during manufacture and storage of processed fruit in order to devise means of preventing or inhibiting undesirable changes such as loss of natural flavors, vitamins, or nutrients; also to prevent the formation of off-flavors and unattractive colors.

---

*A Commodity Project of one of the Regional Research Laboratories administered by the Bureau of Agricultural and Industrial Chemistry. Under Section B of this report, currently active Line Projects are grouped under their parent Research Projects, which correspond approximately in scope to the regular Work Projects of other Bureaus of the Department. Likewise, under Sections D and E, Research Projects are used as the basis for reporting expenditures in 1950, and outstanding accomplishments.

RRL-3-(11)-FP-1-3 - The effect on fruit of applied radiofrequency of other electromagnetic energy. To determine whether high-frequency radio waves would be useful and advantageous in sterilizing or blanching fruits without imparting appreciable cooked or off-flavor to the products.

RRL-3-(11)-FP-1-4 - The microbiology of frozen citrus juices. To devise methods for detecting and evaluating microbial population in processed citrus juices, and to devise methods for the control of the contaminating organisms.

RESEARCH PROJECT RRL-3-(11)-FP-2 - FROZEN, CANNED, DEHYDRATED AND OTHER FOOD PRODUCTS PREPARED FROM FRUITS.

RRL-3-(11)-FP-2-1 - The "dehydrofreezing" of apples, apricots and peaches. To develop a new method of food preservation involving partial dehydration to reduce weight and volume of fruit slices by one-half or more, followed by freezing preservation. Economics in freezing, packaging, storage and transportation costs would be effected by this processing method.

RRL-3-(11)-FP-2-2 - Development of strawberry, blackberry, and raspberry powders. To develop commercially feasible procedures for the manufacture of high-quality strawberry, blackberry, and raspberry powders in order to open up new outlets and increase consumption for these highly perishable fruits.

RRL-3-(11)-FP-2-3 - The freezing preservation of apples, apricots, and peaches. To develop improved methods for the freezing preservation of apples, peaches and apricots. Particular attention is being given to methods of preventing the undesirable darkening and flavor deterioration occurring when the cut surfaces of the fruit are exposed to air.

RRL-3-(11)-FP-2-4 - Development of an improved method of pureeing, deaeration, flash heating (pasteurization), and slush freezing of fruit purees and juices preserved by freezing. To modify the preparation and prefreezing treatment of fruit purees and juices (other than citrus) for the purpose of increasing yields, and, at the same time, to retain or improve the quality of the products.

RRL-3-(11)-FP-2-5 - Developmentof gelled fruit products from fresh or frozen juices, purees and crushed fruits. To devise methods for the preparation of gelled fruit products without the use of heat in order to minimize deterioration of color and loss of flavor.

RRL-3-(11)-FP-2-6 - Development of low-moisture powders from commercially dried prunes, figs, and apricots. To develop commercially feasible procedures for the production of high quality fruit powders of good storage characteristics from commercially dried prunes, figs and apricots. Drying processes such as spray, drum and tunnel drying, are to be used and the processes compared on the basis of quality of products and economic feasibility, with the cooperation of a trade association which furnishes raw material of known history and aids in evaluating products.

RESEARCH PROJECT RRL-3-(11)-FP-3 - APPRAISAL OF UTILITY AND QUALITY OF FRUIT PRODUCTS.

RRL-3-(11)-FP-3-1 - Methods of quality appraisal of fruit products. (Service Project) To develop and refine methods of determining the quality of fruit products, in order to judge the effectiveness of various processing methods and the influence of differences in raw material quality.

RRL-3-(11)-FP-3-2 - Development of fruit products of commercial value from fruit concentrates and related products. (Service Project) To devise commercially feasible procedures for utilization of fruit concentrates and other fruit products in formulated foods, such as ice creams, sherbets, puddings, cakes and pies.

RESEARCH PROJECT RRL-3-(11)-B-1 - INDUSTRIAL UTILIZATION OF THE CARBOHYDRATE CONSTITUENTS OF FRUITS AND THEIR PROCESSING RESIDUES.

RRL-3-(11)-B-1-1 - Isolation and characterization of pectic substances. To develop pectic substances with specific properties and to evaluate their industrial and pharmacological usefulness.

RRL-3-(11)-B-1-2 - Development of industrial uses of pectic substances. To develop pectinate films for protective coatings of food products, pectinate fibers for use in specialized fabrics, and to survey other methods for utilizing pectic substances.

RRL-3-(11)-B-1-3 - Isolation and characterization of sugars and related compounds in cull fruits and fruit processing residues. To provide a background of knowledge for evaluation of possible uses of these materials in the fermentation and other industries.

RESEARCH PROJECT RRL-3-(11)-B-2 - INDUSTRIAL UTILIZATION OF FRUITS OR THEIR PROCESSING RESIDUES THROUGH FERMENTATION.

RRL-3-(11)-B-2-2 - Laboratory development of processes for the production of protein- and vitamin-rich yeast from fruit wastes. To carry out laboratory fermentation investigations essential to the engineering development of a process for the production of torula yeast from fruit wastes.

RRL-3-(11)-B-2-3 - Fermentation as a means of conversion of cull fruit and fruit processing byproducts into useful industrial products. To develop fermentation methods for the production of vitamins, flavors, antibiotics or other useful substances from fruit molasses.

RESEARCH PROJECT RRL-3-(11)-B-3 - FRUIT BYPRODUCT RECOVERY AND UTILIZATION

RRL-3-(11)-B-3-1 - Investigations of the non-carbohydrate constituents of grapes and byproducts. To evaluate the usefulness of grapes as a source of a substance having the pharmacological properties of Vitamin P.

RESEARCH PROJECT RRL-3-(11)-ED-6 - ENGINEERING AND ECONOMIC INVESTIGATIONS IN THE INDUSTRIAL PROCESSING OF FRUITS FOR FOOD. (Partly a Service Project)

RRL-3-(11)-ED-6-2 - Design and development of improved equipment for use in preparing fruits for freezing or drying. To devise better, more efficient equipment for peeling, washing, blanching, cutting, and other operations preceding freezing or drying of fruits.

RRL-3-(11)-ED-6-4 - Development of plant layouts, and equipment designs for fruit freezing plants. To develop improved designs for fruit freezing equipment, and effective freezing plant layouts.

RRL-3-(11)-ED-6-6 - Evaluation of materials for equipment used for fruit dehydration and freezing. To evaluate materials for equipment used in the fruit dehydration and freezing industries, from the standpoints of freedom from undesirable effects on the food and of long life of the equipment.

RRL-3-(11)-ED-6-10 - Processing costs in the freezing of fruits. To estimate the investment and operating costs in fruit freezing plants of different types and sizes.

RRL-3-(11)-ED-6-11 - Engineering investigations of spray drying. To determine the engineering facts required for rational design and operation of spray driers.

RRL-3-(11)-ED-6-12 - Investigation of drying rates of fruits in piece form. To determine drying rates for fruits in piece form, and to put the data in such form that they can be used in the design of driers which will give optimum drying conditions.

RRL-3-(11)-ED-6-13 - Engineering investigations in the pre-processing of fruits in the fluid form in preparation for drying or freezing. To improve the effectiveness and reduce the cost of the preprocessing operations required to prepare fruits in fluid form for drying or freezing.

RRL-3-(11)-ED-6-14 - Engineering investigations in the preprocessing of fruits in piece form in preparation for drying or freezing. To improve the effectiveness and reduce the cost of the preprocessing operations required to prepare fruits in piece form for drying or freezing.

RRL-3-(11)-ED-6-15 - Investigation of cooling and freezing rates of fruit products in refrigerated air. To ascertain cooling and freezing rates for fruit products using refrigerated air as the cooling medium, and to correlate these data into such forms as will be useful in the analysis of freezer performance, and the design of freezers for efficient production of high-quality products.

RRL-3-(11)-ED-6-18 - Cooling and freezing rates of packaged fruit products in refrigerated liquids. To obtain basic data on the cooling and freezing rates of packaged fruit products in refrigerated liquids for use in the design and operation of freezers, and in the analysis of freezer performance.

RRL-3-(11)-ED-6-20 - Cost estimates for fruit products in piece form. (Service Project). To determine probable costs of processing fruits by methods currently under investigation in order to orient research in fruit processing.

RRL-3-(11)-ED-6-21 - Design and development of equipment for the bulk freezing of fruits in package shapes. To devise equipment for the bulk freezing of fruits in package shapes, as a means of simplifying the packaging operation and reducing packaging costs.

RRL-3-(11)-ED-6-22 - Cost estimates for fruit products in other than piece form. (Service Project). To determine probable costs of processing fruits into fluid or comminuted forms in order to orient research in fruit processing.

RESEARCH PROJECT RRL-3-(11)-ED-7 - ENGINEERING AND ECONOMIC INVESTIGATIONS IN THE RECOVERY OF BYPRODUCTS FROM THE INDUSTRIAL PROCESSING OF FRUITS. (Partly a Service Project)

RRL-3-(11)-ED-7-2 - Engineering development of processes for the recovery of pectin from fruit wastes. To reduce the cost of pectin by developing new and more efficient production methods for pectins with special characteristics.

RRL-3-(11)-ED-7-4 - Engineering development of processes for the production of yeasts from fruit wastes. To develop practical plant procedures for the production of yeasts from fruit processing wastes.

RRL-3-(11)-ED-7-6 - Studies on the supply and distribution of fruit processing wastes in the western region. To develop a quantitative picture of the available fruit processing wastes to permit appraisal of raw material supplies for byproduct utilization.

RRL-3-(11)-ED-7-7 - Design and development of process equipment for industrial applications of pectic substances. To devise processing equipment for new industrial applications of pectic substances in order to assist prospective users in adapting the new methods to commercial conditions.

RESEARCH PROJECT RRL-3-(11)-PA-4 - CHEMICAL ANALYSIS OF FRUIT AND DERIVED PRODUCTS.

RRL-3-(11)-PA-4-1 - Determination of the chemical composition of fruit and derived products, and the development or adaptation of methods of analysis for these investigations. (Service Project). To determine the composition of fruit and products derived therefrom and to develop new analytical chemical methods, techniques and apparatus where required.

RRL-3-(11)-PA-4-2 - The analysis of samples of fruit and derived products and the preparation of standard chemical solutions. (Service Project). To make analyses for pectin, sugar, fiber, ash, oil, protein, moisture, calcium, magnesium, sodium, potassium. carbon, hydrogen, amino nitrogen, iron, fluorine, phosphorus, methoxyl, and other constituents. To prepare accurately standardized solutions and indicators for use throughout the laboratory.

RESEARCH PROJECT RRL-3-(11)-PA-5 - X-RAY, MICROSCOPIC, ELECTRONIC, COLOR, AND OTHER PHYSICAL METHODS OF TESTING AND ANALYZING FRUITS AND DERIVED PRODUCTS.

RRL-3-(11)-PA-5-1 - X-ray investigations of fruits and derived products. (Service Project) To determine by x-ray methods the structure and the relationship of structure to physical properties and uses of products derived from fruits.

RRL-3-(11)-PA-5-2 - Chemical-microscopic investigation of fruits and derived products. (Service Project) To determine the optical properties of materials derived from fruits in order to assist in identification of unknown substances and to determine the course of chemical reactions that occur when fruits are processed.

RRL-3-(11)-PA-5-4 - Characterization and analysis of fruits and derived products by electronic methods. To develop non-destructive electronic methods for the characterization and testing of constituents of fruits, and to determine the feasibility of heating by means of high frequency radio waves in processing fruits.

RRL-3-(11)-PA-5-5 - Color as a criterion for evaluating the quality of fruits. To establish reliable methods for measuring the color of fruits and to determine to what extent surface color can be used as a measure of food deterioration.

RESEARCH PROJECT RRL-3-(11)-PA-6 - PHYSICAL CHEMICAL INVESTIGATIONS OF FRUIT PRODUCTS AND CONSTITUENTS.

RRL-3-(11)-PA-6-1 - Spectrophotometric investigations of fruit products and constituents. (Service Project) To develop and apply spectrophotometric methods for the analysis, identification, and characterization of fruit constituents such as those of importance because of their medicinal, nutritional, or flavor properties.

RRL-3-(11)-PA-6-3 - Thermal investigations relating to the preservation of fruit products. To obtain thermal data of basic importance in the freezing preservation of fruits; to determine heat capacities, heat transfer properties, and solubility properties of fruit constituents at freezing preservation temperatures.

C. History and Evolution of This Work.

Early work of the Department in the field of fruit processing dates back to the 19th century. Emphasis was then on canning, and the work dealt principally with contamination by bacteria and fungi and with toxicity caused by metals and added preservatives. With the rapid growth of the fruit-processing industry, and especially of preservation by freezing, a host of new problems arose which could not be solved because of lack of adequate physical, chemical, biochemical, and engineering knowledge.

The Bureau undertook research on such problems, and to meet the specialized needs in certain areas in the United States, it established several field research stations and supported additional research work at State Agricultural Experiment Stations. The work of the field stations contributed in a very significant measure to the development of the large frozen fruit industry as it exists today. During the last war, a pressing need arose for concentrated fruit and vegetable products for the armed forces. The Bureau made important contributions to this problem through technological and engineering studies on food dehydration. Increasing production of fruits during the pre- and post-war periods and loss of many foreign export markets have led to seasonal surpluses. One of the efforts of the Bureau to meet this problem was to organize research work on new outlets for fruits in the form of new and improved food products and through industrial utilization of fruit byproducts. The present unsettled world conditions provide a further stimulus for this work, especially in the direction of making possible the stockpiling of fruits in a concentrated form over long periods of time without the loss of the natural, pleasing flavor and the nutritive value of the fresh fruit.

D. Funds - Annual Expenditures

Considerable work on fruit utilization was done by the Bureau in various laboratories prior to the establishment of the Regional Research Laboratories in 1940.

Annual expenditures between 1941 and 1949 under the fruit utilization project in the Western area ranged from $116,000 to $441,000, averaging about $324,000. The expenditure in 1950 was $442,000, which was apportioned among the various Research Projects as follows:
FP-1, $77,300; FP-2, $98,400; FP-3, $22,000; B-1, $81,000; B-2, $10,000; B-3, $10,000; ED-6, $37,000; ED-7, $40,300; PA-4, $23,000; PA-5, $19,000; PA-6, $24,000.

E. Examples of Outstanding Accomplishments

RESEARCH PROJECT RRL-3-(11)-FP-1.

The role of pectic enzymes in the fruit industry. Pectic enzymes are the important substances which control (catalyze) chemical changes affecting pectin in living fruit and during processing and storage of fruits and fruit products. The chemical changes in the pectin influence in turn the texture of fruit, the clarity of fruit juices and the ease of preparing gels from the fruit. A clear understanding of the way in which these enzymes function is therefore essential to the establishment of successful processing procedures.

Fundamental research in the Bureau has led to the identification of several such enzymes in various fruits, to the establishment of their mode of action (their interdependence), and to practical applications of these findings in the preservation of fruits. The research contributed in a significant way to the improvement of procedures for the prevention of undesirable clearing ("stabilization of cloud") of canned orange juice, and for the prevention of gel formation in frozen concentrates of citrus juice. The information was also used for the improvement of methods for clarification of apple and other fruit juices. The acquired knowledge became directly applicable to the solution of certain problems in the processing of some vegetables, as in the preparation of tomato juice of desirable thickness and in prevention of softening of pickled cucumbers. (SeeFinancial Projects b-1 and b-8). Other applications will undoubtedly be developed from the foundation laid by this research. The results of these investigations are incorporated in three patents.

Improved sanitation in manufacture of frozen orange juice has been achieved by studies of commercial processing procedures to locate potential sources of microbial contamination. Through cooperation with the industry these sources have been greatly reduced. Analytical procedures developed for this work have been adopted by the National Committee on Microbiology of Citrus Products for future collaborative studies. This Committee has representation from the important orange growing areas in the United States.

Development of a quick and simple test for adequacy of heat treatment of processed fruit slices. Heat treatment is used to prevent the development of brown discoloration in fruit slices on exposure to air. A test developed by the Bureau enables untrained factory personnel to determine whether the heat treatment has been long enough to prevent subsequent browning of the fruit.

A rapid method has been developed for determination of Vitamin C. This method is useful in establishing processing procedures yielding maximum retention of this important nutrient. The method, which is applicable to both fresh and processed fruits, is now used in the control laboratories of many food manufacturers.

Contributions to the development of procedures for the manufacture of fruit powders. Although dehydrated, powdered fruits are very desirable and economically attractive products for peace time and, especially, war time uses, the development of a fruit powder industry has been greatly retarded because of processing difficulties. Drying of fruit juices or pulps is made difficult by the formation of sticky, gummy and unmanageable masses which adhere to the walls of the equipment. Preparation of powders on an experimental scale has shown that a further difficulty arises from their caking in storage containers. Several investigations carried on under this research project have contributed to a solution of these problems.

(a) Reduction of stickiness of fruit powders through the use of various additives has been investigated. The work has led to the discovery of a substance that may make it possible to prepare certain fruit powders in commercially available spray-drying equipment, such as is used for dried milk or eggs. The use of this additive (a cellulose compound which is non-toxic, odorless and tasteless) has been protected by a public-service patent.

(b) A testing method to measure the stickiness of fruit powders has been developed. With this method it is now possible to determine how the stickiness of different fruit powders is affected by temperature, humidity, moisture content and other factors.

Design and operation of drying equipment is dependent on such knowledge.

(c) Fundamental investigations on the causes of caking in fruit powders have shown that one of the causes is the liberation of water which occurs when fruit sugars are transformed from the glassy to the crystalline state. The exact conditions at the time that this transformation occurs have been established; this information is of direct usefulness in defining packaging and storage requirements for the prevention of caking in fruit powders.

Determination of moisture in dehydrated fruits. One of the important requirements in specifications for dehydrated fruits is a definite moisture content. The measurement of the amount of moisture has long been the subject of much controversy among food manufacturers and procurement agencies, because the analytical methods employed were not sufficiently standardized to assure agreement in results of different laboratories. A new and accurate analytical method for moisture, developed by the Bureau, should be helpful in avoiding such disagreements by serving as a calibration standard for the methods now used in the industry. The new method assumes a particular importance at this time when an increasing amount of dried fruit is being bought by the armed services on the basis of definite moisture specifications.

Prevention of browning in frozen-fruit purees requires a heat treatment to destroy the enzyme (polyphenolase), that is responsible for the discoloration. The exact times and temperatures required for the enzyme destruction have been determined for apples, pears, apricots, grapes, and peaches, in response to numerous requests for this information from various fruit products manufacturers. The data obtained are essential for the design and operation of equipment for the manufacture of stable (non-darkening) purees.

RESEARCH PROJECT RRL-3-(11)-FP-2

Development of the frozen fruit industry in the Northwest. Through a research program responsive to the needs of a growing industry, the Department played a leading role in the development of the frozen-fruit industry. The conversion of surplus ripe fruit to a stable, profitable article of commerce was expedited by timely answers to practical problems, such as the selection and handling of raw materials for the maintenance of the highest qualities in color, flavor and texture; the use of additives to the fresh fruit to insure the retention of these qualities; the development of effective and economically feasible methods for freezing and holding in frozen storage; the identification of bacterial contamination as a factor in loss of quality and the need for rigid sanitation in all phases of fruit handling and the freezing operation; and the selection and standardization of the containers so essential to good freezing and adequate product protection.

Because of close cooperation with industry, findings of the Department laboratories have been translated rapidly into commercial practice. The accumulation and distribution of results were expedited further by collaboration with State agricultural experiment stations, equipment development companies, and distributors. This teamwork has been largely responsible for the growth of the Northwest frozen-fruit industry from a meager beginning two decades ago to its present status as a multimillion dollar enterprise.

New fruit products from fruit purees. Formulas and processes of manufacture have been developed for "Velva Fruit," a frozen fruit dessert, and for a fruit spread, both preserved by freezing. Since the fruit ingredients in these products are not heated above ordinary atmospheric temperatures at any time during their preparation, distribution and serving, they retain the color, flavor, and to a very high degree, the nutritive value, of the fresh prime-ripe fruit.

Velva Fruit has a soft, smooth texture similar to that of ice cream, yet its ingredients contain at least 60 percent fresh or frozen fruit. It has been demonstrated that strawberry Velva Fruit, for example, retains as much as 84 percent of the usually elusive Vitamin C present in the original fresh fruit.

The fruit spreads, possessing a spreadability comparable to that of the best jellies and jams, are made without the aid of heat and have the unique quality of retaining all of the flavor essences that are otherwise largely lost in a heat-processed product. A public service patent has been granted to the Department on the basis of this discovery.

Velva Fruit and the new fruit spreads are in process of evaluation by commercial organizations, and have been produced commercially in limited amounts.

Elimination of mold-like growth in frozen-fruit gels. Formation of harmless, but unsightly and mold-like growths of sugar crystals in frozen gels was prevented by replacement of part of the dextrose sugar in the gel by invert-sugar sirup, and by storage of the gel in hermetically-sealed containers. (See also accomplishments for Research Project RRL-3-(11)-PA-6.)

Treatment for prevention of browning in frozen apple slices. In packing frozen apples it is necessary to provide suitable pre-freezing treatment of the apple slices in order to prevent undesirable discoloration and off-flavor formation during freezing storage or while the product is being defrosted. Bureau scientists worked out a procedure for freezing apples, based on use of sulfites, which provides a practical solution to this problem. All of the necessary technical details of this procedure, including control methods, have been worked out, and adequate directions have been provided for plant operators. A large percentage of the frozen apples packed in the western states is processed according to this procedure.

Treatment for improvement of texture of frozen apple slices. A treatment has been developed to overcome the softness and flabbiness of flesh found in ordinary frozen apples. The treatment involves impregnation of the raw slices with sugar sirup through use of vacuum. Additives, such as ascorbic acid, are incorporated in the sirup for prevention of browning of the apple tissue. The treated slices are then frozen in the usual manner. Frozen "sirup-filled" apple slices are excellent for use in pies, since they retain their shape and their juices better than do ordinary frozen apple slices. When compared in baked form, the texture of "sirup-filled" apple slices is comparable to that of fresh apples. This procedure is being evaluated by commercial organizations.

Dehydrofreezing. Expenses of packaging, transportation and storage are major portions of the cost of fruit products to the consumer. Dehydration can reduce these costs considerably, but frequently the products are difficult to rehydrate or have suffered other quality losses. The desirability of reducing weight and volume without quality loss led to the development of a new processing method, called dehydrofreezing. The process combines partial dehydration with preservation by freezing in such a way as to achieve much of the weight and volume reduction attainable through dehydration, with the quality advantages and convenience of preparation of conventional frozen products. The process has given good results with apples, apricots, and prunes, and has been applied in a preliminary way to peaches and red sour cherries. According to present estimates, dehydrofrozen apple slices would be competitive with pie-grade apple slices processed by canning or freezing, the slightly higher preparation cost being offset by lower packing and freezing costs. Savings in subsequent storage and transportation costs make the process economically attractive. The most promising field of use so far indicated has been in pie fruit. Dehydrofrozen apple slices and halved apricots, prepared in pilot-plant-scale operations, have been tested in commercial bakeries and considered adaptable to bakery pie preparation. In many respects, these products are regarded by bakers as superior to the processed apples and apricots they are now using.

Many inquiries have been made by commercial fruit-processing concerns, and one major corporation has plans for test-marketing dehydrofrozen apple slices when equipment for full scale production has been developed and tested. The market test would involve nearly one million pounds of apples.

Present work on this project is concerned with the development and testing of large-scale equipment. A public service patent has been granted to the Department of Agriculture on this new process.

Study of losses occurring during processing of apples. Losses of soluble solids from fruits during processing, particularly in dehydrating, present a serious problem to the fruit-processing industry. It has been conservatively estimated by members of the industry that hundreds of thousands of dollars' worth of fruit solids are lost annually during processing. Such losses not only result in lower-quality products which must be sold to the consumer at a higher price, but also they increase the load on the already overtaxed waste-disposal systems. A laboratory study simulating procedures used in apple processing has been made in order to determine where these losses occur and the magnitude of the losses. For example, it was found that an immersion procedure commonly used in the canning of apple slices results in the loss of almost half of the soluble solids during processing. The information obtained has been made available to the apple processing industry together with recommendations on ways of reducing these processing losses.

Preparation of single-strength and concentrated juices from fresh prunes. Important contributions have been made toward the development of new products from prunes as a means of increasing per capita consumption and consumer acceptance of this fruit. At the suggestion of the California Prune Marketing Program Committee and the Washington State Fruit Commission, procedures suitable for the commercial preparation of single-strength and concentrated juices from fresh prunes have been developed. These new products, prepared from fresh fruit, differ from the conventional extract of dried prunes commercially marketed at the present time in that they are clear, with a pleasing wine color, and retain the characteristic flavor of fresh prunes. Results of a limited consumer acceptance test of samples prepared by the process is being considered by prospective manufacturers.

Development of new methods for preparing powders from dried figs and prunes. Surpluses of prunes and figs have been particularly troublesome in the post-war years and have pointed out the desirability of more diversified uses for these products. New and less expensive procedures have been developed for preparing low-moisture fruit powders suitable for use in a variety of bakery products and breakfast foods. The smaller sizes of prunes and figs, which are of good quality but not readily marketed in regular commercial channels, are used in this process. The armed services have expressed great interest in these products and are at present evaluating them.

RESEARCH PROJECT RRL-3-(11)-FP-3

Evaluation of fruit products. Work under this project consists of service to Bureau units engaged in process and product development, and has contributed to accomplishments mentioned under other projects listed in this report. As the decision to produce a new product is frequently based upon tests of eating quality, it is important that the tests be reliable. The work involves use of taste panels for determining differences in flavor, taste, and texture, etc., between samples of fruit products processed or stored in various ways. Progress has been made in refining the testing methods to allow more accurate judgments. A significant contribution is the development of a superior lighting technique, employing pure (monochromatic) light to mask color differences between samples. Under this condition, judgments of flavor and texture can be made without prejudice caused by variations in color. This form of illumination is considered a definite advance in the technique of food-appraisal work, and it has been adopted by other institutions doing the same type of work.

RESEARCH PROJECT RRL-3-(11)-B-1

An important approach to reduction in costs of fruit processing lies in the more efficient utilization of cull fruit and processing wastes. Recovery of valuable products from the waste pile is advantageous also as a means of decreasing the mounting nuisance problem attached to the disposal of fruit processing wastes. Pectin, the common jellying agent from citrus peel and apple pomace, is a typical example of a valuable byproduct from waste. The demand for ordinary pectin is not large in proportion to the potential supply because of its cost and its limited applications in jams, jellies and preserves. Development of modified forms of pectin is a promising means of extending uses for this byproduct. Work along this line has involved a basic study of pectin, the preparation of new pectic materials and development of new uses for them.

Fundamental studies of pectin. An extensive knowledge of the structure and chemical properties of pectin was required to facilitate the development of new pectic products. For example, its reaction with acid, alkali, and enzymes was studied in detail to determine the best conditions for extraction of pectin from fruit wastes and for modification of pectin to more useful materials. This study, in conjunction with determination of molecular weight, acid behavior, and gel properties of pectin, established that a pectin chemically modified in alkaline solution to have a lowered content of methoxyl groups (3 to 3.5 percent) would have many characteristics desirable for a gelling agent in the food industry. Molecular weight and x-ray studies (see accomplishments under RRL-3-(11)-PA-5) showed that the brittleness of pectinate films and fibers can be explained by the tendency of pectinates to crystallize. This finding points the way for development of other modifications of pectin which will overcome this limitation and open new commercial possibilities. Fundamental studies have contributed in many important ways to the accomplishments which are described in the following sections.

Preparation of an improved low-methoxyl pectin. A much wider usage of pectin would be possible if its properties could be altered to form films, fibers, and gels containing milk solids. Commercial low-methoxyl pectins available for such gels were variable in composition, and had a methoxyl content higher than was indicated to be desirable by fundamental studies. Laboratory investigation proved that by use of alkali at low temperatures to remove the methoxyl groups from pectin, an improved low-methoxyl pectin could be made. A new and more economical method for preparing this new pectic product was developed. In this method, the pectin is isolated by precipitation with acid instead of with the commonly-used alcohols, which require expensive equipment for their use. Both the alkaline treatment and the precipitation of low-methoxyl pectin by acid have been studied on a pilot plant scale and have been shown to be economically feasible (see accomplishments under RRL-3-(11)-ED-7).

Valuable new uses for the improved low-methoxyl pectin. Some of the important applications found for low-methoxyl pectin are as follows:

An edible film and coating material. Many foods such as dried fruit, candied fruit, or salted nuts are difficult to handle because of their stickiness or greasiness. Low-methoxyl pectin can be used to coat such foods to eliminate these disadvantages, and the Quartermaster Corps has issued specifications for pectinate coatings on its emergency ration bars. Several companies are investigating the use of pectinate coatings on dates, candied fruit, glaced pineapple and salted nuts. The fact that the coating can be used to apply dyes, flavors, preservatives, antioxidants, and vitamins, holds promise of new uses for low-methoxyl pectin.

Low-sugar gels for food use. A procedure for the preparation of a milk pudding containing low-methoxyl pectin has been developed. Preparation of the pudding requires only the addition of water to the dry mix followed by a three-minute stirring period. The convenience, palatability and other desirable characteristics of the procedure have interested commercial concerns who are studying its possibilities.

Pectinate fibers. A procedure has been devised for producing a pectinate fiber which is soluble in dilute soda or phosphate solution. This fiber may find use as a scaffolding in weaving specialty fabrics.

New gel tester. A new instrument to measure the characteristics of gels has been designed and developed. It is being examined by producers of pectin and jellies as a control instrument for the manufacture and standardization of these products. It is useful also for testing other food products, such as cake mixes, mayonnaises, oils, etc.

New analytical method for pectin. Processors of foods and pectin manufacturers require a knowledge of the pectin content of their processing liquors to satisfactorily control the treatments to be applied. In the past, methods for determination of pectin have been time-consuming, eliminating the possibility of close process control of the soluble pectin. A new method, based upon the optical activity of pectin, has been developed and has been adopted by many laboratories.

Fibrous pectinic acid. Because pectin is combined with certain metals in plant tissue, heat and strong acid must be used for its extraction. This leads to some decomposition and loss of material. By converting the pectin in citrus peel to a low-methoxyl pectin, then washing with dilute acid, it is possible to extract the pectic material under milder conditions. During the course of this work, the presence of an active enzyme capable of producing a low-methoxyl pectin was confirmed. (See accomplishments under RRL-3-(11)-FP-1.) By using this enzyme in situ, followed by an acid wash, there can be isolated a pectic product which forms strong films and fibers. The cost of production of this material should be low and it should eventually find many uses.

RESEARCH PROJECT RRL-3-(11)-B-2

Production of torula yeast. There is available from canneries a considerable quantity of peels, cores, and cull fruit which must be disposed of without polluting streams or causing bad odors or other nuisances. One outlet developed for this waste involves pressing it and using the juice as a medium for the growth of torula yeast. The press cake is readily dried for use as animal feed, while the yeast is a rich source of protein and vitamins of the B complex, and consequently is a valuable feed supplement. Methods of production on a laboratory scale have been developed, and this knowledge is now being applied to studies on a pilot plant scale. (See also accomplishments for Research Project RRL-3-(11)-ED-7.)

RESEARCH PROJECT RRL-3-(11)-B-3

"Vitamin P" obtained from grape pomace and raisin seed meal. A method has been developed for the isolation from grape pomace and raisin seed meal of a substance that is active in reducing capillary permeability. As this substance, formerly called Vitamin P, prevents certain harmful effects of frostbite and atomic radiation, a method of recovery from a rich new source might be of great importance in event of emergency.

Grape pomace effective as additive to oil well drilling mud. In cooperation with the U. S. Bureau of Mines it has been found that in certain types of drilling muds, grape pomace is effective in retaining the moisture and the viscosity at desired levels. Tests by petroleum companies are under way.

RESEARCH PROJECT RRL-3-(11)-ED-6

Development of improved heat-treating equipment and methods. New methods have been developed for heat-treating fruit and vegetable juices and purees with minimum heat damage. The heater has been successfully used for operations such as pasteurizing, sterilizing, and inactivation of enzymes, and for preheating as a step in operations involving partial vaporization. The new heating devices are able to heat fluids to temperatures in excess of 300° F. in less than one second. The units are able to effect heating and vaporization very rapidly and to handle materials which can not be processed in conventional equipment. The devices are especially useful on heat-sensitive materials or on materials which cause fouling of heat-transfer surfaces. One of the most important applications of the equipment is likely to be in the field of milk processing. Further research, including cooperative studies with industrial concerns, is under way in order to bring about commercial use of the new procedures.

Treatment of berry-picking boxes to reduce mold growth. Methods were developed for coating wooden berry-picking boxes, used by processors, with a wax to reduce mold damage to the boxes and to minimize berry losses which occur when sound berries are picked and placed in mold-infested containers. The problem of mold damage has been a serious one to both growers and processors in the Pacific Northwest in recent years. This work has resulted in wider use of wax-treated boxes by the industry. It is difficult to estimate the monetary value of the accomplishment, but with an estimated 30 million berry boxes in use in the western states alone, representing an annual investment of about $450,000, the use of wax-treated boxes can save the western industry something like $300,000 a year by tripling the useful life of the containers. The amount of berries saved from mold damage each year is even more difficult to evaluate. Available information indicates that the savings in berries would far exceed the savings in box replacement.

Survey of the apple industry in the Pacific Northwest. In cooperation with, and at the request of, the Rural Agricultural Credit Corporation, a survey of the apple-processing industry in the Northwest was carried out to provide technical and statistical information. Recommendations based on this information were used by the R.A.C.C. in its action programs in the apple-producing area of the Northwest. The results of this survey were used to help stabilize the overall price structure of apples for processing and to permit equitable price differentials between various grades, sizes, and varieties of apples. Factors evaluated in making this study included determinatio of: (1) quantities of various grades, sizes and varieties of apples available for processing; (2) cost of dehydrating apples; (3) cost of canning apples; (4) facilities for processing apples; and (5) facilities and costs of storing apples.

Comparative costs of various methods of supplying apples for pie stock. A study was made of the comparative costs to the bakery trade in a representative middle western city of obtaining apples for pie stock. The probable costs of various methods of processing apples in the Pacific Northwest and shipping them to the market, and the probable costs of fresh apple slices prepared in the mid-west city, were calculated. The results of this study are valuable to growers and processors in determining the most economical method of marketing the fruit. This study also points out which processes justify further research. New processes were included in the evaluation, and the important factors influencing costs were determined.

Possibilities for industrial utilization of fruits in the Columbia Basin. At the request of the Columbia Basin Joint Investigations Committee, a study was made of the possibilities for industrial utilization of fruits and other farm products that might be produced in the Columbia Basin area when the land is brought under irrigation. The results of the study were incorporated into a report prepared by the Committee and were used in the overall planning for the Columbia Basin.

Compression of dehydrated fruits. Procedures were developed during World War II for compressing dehydrated apples, apricots, peaches, prunes, and cranberries into blocks in order to save shipping space during the war. Bulk reductions ranging from 40 to 70 percent for various fruits was accomplished without significant impairment of the quality of the products. The procedures were included in a dehydration manual.

RESEARCH PROJECT RRL-3-(11)-ED-7

Pectin production from citrus peel. A process based on laboratory-scale experiments (see accomplishments under RRL-3-(11)-B-1) has been worked out on a pilot-plant scale for the production of high-quality, low-methoxyl pectin from dried and fresh citrus peel. Information regarding equipment and operating and control procedures is available to prospective manufacturers of the product. Cost studies indicate that commercial application of the procedures developed in the pilot-plant study would bring about a marked reduction in the cost of low-methoxyl pectin.

In order to extend the operating season for the manufacture of low-methoxyl pectin, dried citrus peel of high quality must be available when fresh citrus fruit is not being harvested. Specifications for suitable dried peel were established, and practical procedures for preparing such peel were worked out on a pilot plant scale. Both specifications and operating procedures are available to prospective manufacturers.

Yeast propagation methods developed on a pilot-plant scale. A process based on laboratory-scale experiments (see accomplishments under RRL-3-(11)-B-2) was developed on a pilot-plant scale for the continuous production of feed yeast from fruit-waste juices. The process is characterized by a higher productivity than has been reported for any other method of propagating yeast, and may lead to a marked reduction in the cost of producing feed yeast.

Fundamental engineering studies on the recovery of juice from fruit-cannery wastes. One of the most important factors affecting the cost of production of feed yeast from fruit juices is the cost of preparing the juices from fruit wastes. Fundamental studies were carried out on the pressing characteristics of pear-cannery waste, which is the waste that occurs in largest quantities and is the most difficult to handle. The results of these studies have been applied in the development of practical methods and equipment for handling the cannery wastes. The results of this work are now being applied under RM:a-307 in a large pilot-plant operation on fruit-cannery wastes in cooperation with a number of commercial canners.

Studies on the recovery of calcium tartrate from brandy-still slops. As a war emergency measure, practicable methods for the recovery of calcium tartrate from brandy-still slops were developed on a pilot-plant in the plant of a cooperating winery. A cost analysis was made to determine under what conditions the process would be economically feasible. It was concluded that the process would be uneconomical under ordinary peacetime conditions, but would be well worth using in the event of a critical shortage of tartrates during a national emergency.

RESEARCH PROJECT RRL-3-(11)-PA-4 (Service Project)

The work carried on under this research project is of a service nature. The many chemical analyses performed and new techniques and methods of analysis developed under this project have been of direct use in the successful completion of many of the accomplishments reported under other research projects. In many of the investigations performed on fruit and fruit products, the identification and/or characterization of the material used, and the changes which occur during storage or processing, require a large number of chemical analyses.

The following analytical methods are examples of those developed to meet the needs for special analyses arising under other research projects:

(1) A rapid method for the determination of water in fruit purees and juice concentrates; (2) a rapid method for determining calcium in apple firming baths; (3) a method for determining small amounts of pectin; (4) a rapid method for determining the moisture content of fruit powders; and (5) a rapid polarographic method for determining the amount of levulose sugar in the presence of other sugars.

RESEARCH PROJECT RRL-3-(11)-PA-5 (Partly a Service Project)

Extension of uses for fruit pectin through fundamental physical studies. The restricted use of pectin is due partly to the lack of knowledge of its structure and of its physical and chemical properties which determine the potential usefulness of this material. To determine how the molecule is put together, an x-ray study was made of pectin and of a variety of pectin derivatives, under conditions of different moisture content. As a result of this work, the geometrical configuration and the mechanism of water absorption of these substances are now relatively well understood. This information has been useful to other workers in the Bureau, in the development of pectin films which are strong and pliable, and have low oxygen permeability.

A study of the thermal degradation and kinetics of certain chemical reactions which are used to modify pectin, has been completed. This work has been useful in defining the types of treatment that pectin can be subjected to without destroying its valuable gelling properties.

Determination of the reflectance color of lemons. The citrus industry has needed an improved sorting method based on color, in connection with the packing and storage of lemons. Such sorting would assure that a uniformly ripe product would be available for shipping or for processing. To aid in the solution of this problem, an investigation of the fundamental color characteristics of lemons in various color grades has been made. This information was used by the California Agricultural Experiment Station as a basis for the development of a pilot-plant model of an automatic mechanical color-sorting machine that can selectively sort lemons on the basis of color at the rate of five per second.

Spectroscopic determination of trace amounts of metallic contaminants in fruits. Trace amounts of metallic contaminants present as insecticide residues, or picked up from processing equipment and storage containers, may cause deterioration in the quality of fruit products, and in extreme cases may be toxic. Special analytical methods were needed to detect such contamination, because existing methods which had been developed for analysis of metals and alloys, were not applicable. Rapid and reliable spectrographic methods have been developed for the simultaneous quantitative determination of lead, iron, copper, tin, aluminum, zinc, boron and nickel, and for qualitative detection of other possible metallic contaminants in fruit products. Applications to studies correlating loss of quality with metal contamination have contributed to the improvement of processing techniques and storage practices for fruit products. The methods are adaptable for control purposes in fruit-processing plants.

RESEARCH PROJECT RRL-3-(11)-PA-6 (Partly a Service Project)

Discovery of sucrose hydrates. Fundamental information on the behavior of sugar sirups at freezing temperatures is needed as a guide to further developments in the processing and storage of frozen fruits. A thorough investigation of the behavior of ordinary sugar (sucrose) solutions throughout the temperature range used for freezing preservation of fruit, has resulted in the discovery of seven previously unknown crystalline compounds (sucrose hydrates) containing ordinary sugar (sucrose) and water in various proportions. These hydrates usually grow in cauliflower-like clusters or as fine needles. In sirups such as are commonly used in frozen fruit preservation, these hydrates will melt completely during thawing, but on cooling to sufficiently low temperatures (below 10° F.) they will cause the entire sirup to solidify to a dry, hard mass. Knowledge of the properties of these hydrates assumed practical importance when the objectionable white growth which sometimes occurs in stored frozen fruit packed in sugar, or sugar sirup, was identified as one of these hydrates.

Additional work indicates that the growth of these hydrates in sugar sirups can be controlled effectively by the replacement of part of the sugar by invert sugar. It was also found that although hydrate growth is most rapid at about -10° F. (a common storage temperature), it is negligible at -30° F. During this work it was found that glucose crystallizes readily in a hydrate quite similar to sucrose hydrates, and hence is not satisfactory for use in sirups with frozen fruit, although glucose does repress the growth of sucrose hydrate.

(See also accomplishments for Research Project RRL-3-(11)-FP-2)

Discovery of levulose dihydrate. An investigation of the behavior of fruit sugar (levulose) solutions at low temperatures resulted in the discovery of a new crystalline compound (levulose dihydrate) containing levulose and water. The favorable crystallization and solubility properties of levulose dihydrate suggest its use in the purification of levulose, which is now too expensive for widespread use in spite of its desirable qualities of exceptional sweetness, high solubility, and natural blending with fruit flavors.

Instrument for measuring ethylene concentrations in citrus coloring rooms. In response to a need expressed by the citrus industry for a reliable method of measuring and controlling the concentration of ethylene gas in the atmospheres of coloring rooms in citrus packing houses, an easily-operated, portable instrument was developed for rapidly measuring ethylene concentrations in the range of 5 to 200 parts per million of air. Use of this instrument will make it possible to avoid considerable economic loss now occurring due to degrading of fruit caused by over-treatment with ethylene.

Characterization of the bitter principles in navel orange juice. The bitter taste which develops in processed navel orange juice has restricted the commercial development of this product. A major obstacle to the solution of this problem has been the lack of definite information about the properties of substances which cause the bitter taste. To meet this need, the optical properties of these materials have been determined by the methods of chemical microscopy. This information is now being used by other workers in the Bureau who are engaged in a thorough study of the chemical reactions and the characterization of the compounds responsible for the bitter taste which develops in navel orange juice. (See accomplishments under b-8 and RM:a-504).

F. Some Additional Work Needed

Fundamental investigations of flavor and color deterioration in processed fruits. Many undesirable changes in flavor and color occur during prolonged storage of processed fruits, especially in those preserved by dehydration. The most evident of these changes is a browning which detracts from the appearance of the fruit and is accompanied by an alteration in flavor. This change is different from the so-called enzymatic browning which occurs on cut or bruised surfaces of certain fresh fruits. The browning may be retarded for a limited time by the use of certain chemical preservatives, but these preservatives in themselves impart a foreign flavor and can be used only in small quantities. Prevention of this deteriorative process, which shortens the shelf-life of the products, has been hampered by inadequate knowledge of the chemical reactions that are responsible for the changes. Fundamental information is therefore necessary to explain the nature of the deteriorative changes and to devise methods for preventing them. The problem is of particular importance to the armed services, who frequently must stockpile large amounts of dehydrated fruits under adverse storage conditions.

Development of procedures for concentrating liquid fruit products by freezing. The methods currently used for the concentration of certain fruit products suffer from the disadvantage that the natural aromatic flavors of fresh fruits are either lost or altered, or new undesirable flavors are introduced during the processing. Since concentrated fruit products, such as purees or juices, are becoming increasingly popular and important in both peace and war economies, improvement of the quality of such products seems most desirable. Concentration, by freezing and separation of excess water, appears to be a promising way of accomplishing this objective. No satisfactory continuous procedure and equipment have been developed for this purpose. Research is therefore needed to determine the technical and economic feasibility of the freezing concentration method.

Use of antibiotics in fruit preservation. It has recently been shown that certain antibiotics, particularly subtilin (a substance somewhat similar to penicillin in its bactericidal action), show possibility of reducing spoilage in various types of canned vegetable products. Shorter sterilizing times at lower temperatures, with notable improvement in product quality, may prove to be practicable as a result of this research.

Research on the use of antibiotics in the preservation of canned foods should be extended to cover other types of canned foods, particularly fruits.

Preservation of natural color in processed fruits. Fundamental investigations are needed to find the conditions for maximum color retention, and to develop inhibitors to retard or prevent deterioration, of fruit pigments in processed fruits. This is of special importance for highly-colored fruits, such as berries or grapes.

Stability in storage of liquid fruit products sterilized by ultra-rapid procedures. Liquid fruit products, such as juices, of unusually good quality have been prepared by a process involving extremely rapid heating (sterilization), cooling, and filling into sterile containers. Research on the storage life of such products, as compared with those prepared by conventional methods, is needed to evaluate the merits of the rapid process.

Fundamental study of enzymes that influence changes in color and flavor of processed fruits. While there is evidence of the existence in fruits of numerous enzymes (complex and ustable chemical substances) capable of effecting deteriorative changes in the color of flavor of fruit products, none of these enzymes has been isolated in pure form. Progress in the development of methods of preventing these deteriorative changes is dependent upon further advances in our knowledge of these enzymes. It is important, therefore, that these substances be isolated and purified, and their chemical properties determined.

Development of improved dehydrated fruits. One of the chief reasons given for the declining popularity of dehydrated fruits is their lack of convenience, due to slowness in rehydration. Other reasons are incompleteness of rehydration, lack of fresh fruit flavor, and lack of stability in storage at elevated temperatures. In view of their strategic importance in wartime and their economic advantages in peacetime, it is important that further research should be carried out on methods of preparing dehydrated fruits to improve their quality and convenience in use.

Dehydrofreezing of cherries, prunes and various berries requires investigation to determine the possibilities of this new method of preservation as a means of improving texture and quality, and to reduce the costs of transportation, storage and packaging of the fruits. The applicability of this method, combining the advantages of dehydration and freezing, has already been demonstrated for apples and apricots.

Broader knowledge of the constitution of pectin and the nature of its functions and properties in plant materials is necessary in order to improve the quality (especially the texture) of processed fruits. Such knowledge would aid in developing new and more economical procedures for the production of pectin, methods for reducing brittleness and tear resistance of pectinate films, and improved methods for application of pectinate films.

Byproduct utilization of fruits and their processing residues. Cull fruit and fruit processing residues have not been sufficiently investigated to determine their possible utilization for the production of valuable commercial products. Valuable nutritional factors may be present in sufficient amounts in fruit byproducts to be economically extracted for use in feed supplements and in pharmaceuticals. Conversion of fruit residues into insect baits, soil conditioners, and feeds requires further attention to develop profitable outlets for this ever-increasing problem.

Fermentation of processing residues into new and valuable products holds considerable promise. The production of fruit molasses for fermentation to alcohol, solvents, vitamins and flavoring agents could utilize large quantities of such residues. Fermentation to yield protein-rich feed and food supplements would be useful in times of emergency and, if sufficiently bland products were produced, they would be valuable in human diets because of their vitamin and protein content.

Various improved equipment designs and operating procedures for the spray-drying of food products should be tested. Limited pilot-scale tests indicate that substantial contibutions have been made to spray-drying technology. Comprehensive tests on a variety of food products are necessary to appraise the contributions fully, and make the results of the work available for commercial application.

Promising and improved processes and equipment for the heat processing of fluids, including operations such as pasteurization, deodorization, heat stabilization, and concentration, should be tested exhaustively. The developments have been worked out on a pilot-plant scale, but must be tested on a variety of products and on a commercial scale in order to establish the importance of the work. Because of the novel character of some of the methods developed, considerable testing of the procedures under commercial conditions will doubtless be necessary before any extensive adoption of the methods by industry can occur. From two to four years of supervised application studies are anticipated.

Cooling and freezing rates during immersion freezing of packaged foods should be established quantitatively in order to relate processing procedures with product quality, and to provide a rational basis for the design and efficient operation of commercial freezers. The importance of such studies is becoming increasingly evident as frozen fruit juice concentrates and other frozen liquid products are being placed on the market and new processing methods for the manfacture of these products are being developed.

Successful commercial application of a process for the production of feed yeast from fruit wastes will require cooperative study with industrial groups. The process has been worked out on a pilot-plant scale and compares favorably with other reported methods. Cooperative studies with industrial concerns are needed in order to obtain the information upon which commercial use can be based.

Cost studies on processing developments. Cost studies have shown the economic advantage of high-unit-value processed products, for example, fruit concentrates, especially from the standpoint of competition in distant markets. Processes for high-quality concentrated fruit products in either liquid or solid form and with low transportation and marketing costs are needed. Concentrated products are also of great value in feeding military personnel and for shipment to foreign countries. The market position of new processes and products is often dependent upon the ability of the products to compete costwise with similar products. The cost of research may likewise be influenced by the results of product-cost relations. A continuing program of processing cost studies is, therefore, necessary to the planning of research studies for the attainment of best overall economic results.

Development of improved procedures for color measurement in raw and processed fruits. Color is a very evident characteristic of fruits and is recognized as an important factor in quality grading. Fundamental physical data on natural color variations due to maturity, locality, and seasonal factors, as they affect processing, are needed in order to establish improved objective color-measurement methods and automatic color-grading and color-sorting techniques. Measurements need to be made of color variations introduced by processing and storage as an aid in evaluating freezing, concentrating, and other food preservation procedures.

Use of high-energy radiation for preserving fruits. Preliminary reports from other laboratories on the use of high-energy radiation, such as x-rays and electron beams, indicate that these treatments hold considerable promise as a method for preserving certain types of fruits. More detailed investigations need to be carried out, however, in order to evaluate the actual potentialities of these treatments.

Identification of aromatic volatile substances. The techniques of microwave spectroscopy need to be developed in order that the volatile substances given off by fresh and processed fruits when stored can easily and accurately be identified. This information is needed in order to find methods for improving storage stability.

UTILIZATION INVESTIGATIONS ON FRUITS OF THE EASTERN REGION *

(BAIC - RRL-4-3 - Federal-State - Regular Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To develop for apples and other fruits, exclusive of strawberries, cherries, black raspberries and peaches, new and extended uses that will provide an outlet for the lower grades of fruits and for surpluses. Current work is on the improvement of commercial apple juice. Such improvement would result in greater consumption and hence in a greater use of apples. Further emphasis has been on the recovery of the fragrant fraction of fruits in concentrated form for use in improving the flavor of concentrated juices, jellies and jams and on the development of pectin, low-sugar preserves, malic acid, sirups, and confections.

B. Currently Active Line Projects

RESEARCH PROJECT RRL-4-(3)-B-1 - CHEMICAL RESEARCH ON APPLE AND OTHER FRUIT UTILIZATION

RRL-4-(3)-B-1-2 (Rev.) - Concentration of apple juice. To improve the quality of apple concentrate and to develop new uses for it. Because of extreme variation in quality, concentrated apple juice has limited usefulness. Industry needs to know how to make a good, uniform product. A new type, with the volatile flavors added back, could command a new market.

RRL-4-(3)-B-1-4 - Utilization of apple pomace. To develop economic outlets for pomace from cider and vinegar operations. Only about 10% of the pomace produced is utilized, and that for pectin. Other uses are needed.

RRL-4-(3)-B-1-5 - Processing of apple juice. To devise improved means of commercially processing apple juice, cooperatively with National Apple Institute, Virginia Agricultural Experiment Station, and Tennessee Valley Authority.

RRL-4-(3)-B-1-8 - Uses for apple thinnings. To develop uses for the immature apples picked for thinning purposes. Most of this work is done cooperatively with the Virginia Agricultural Experiment Station.

RRL-4-(3)-B-1-10 (Rev.) - Firming of apples. To develop methods for the firming of those varieties of apples which become undesirably soft when cooked. The purpose is to maintain slices for pies without

---

* A Commodity Project of one of the Regional Research Laboratories administered by the Bureau of Agricultural and Industrial Chemistry. Under Section B of this report, currently active Line Projects are grouped under their parent Research Projects, which correspond approximately in scope to the regular Work Projects of other Bureaus of the Department. Likewise, under Sections D and E, Research Projects are used as the basis for reporting expenditures in 1950, and outstanding accomplishments.

mushing.

RRL-4-(3)-B-1-11 - Chemical constitution of apples and other fruits. To isolate, identify, and study the constituents of fruits, especially apples, and to study the unknown constituents of apples, which amount to 10% of the total solids. This information would be a guide for the more intelligent development of the various apple products. It could also conceivably uncover new substances of special value.

RESEARCH PROJECT RRL-4-(3)-E-1 - CHEMICAL ENGINEERING STUDIES ON THE UTILIZATION OF APPLES

RRL-4-(3)-E-1-3 (Rev.) - Miscellaneous chemical engineering services. To give advisory chemical engineering service to other divisions of the laboratory, to make cost estimates on proposed processes, to prepare graphs and drawings and to do other routine work.

RRL-4-(3)-E-1-16 (Rev.) - Chemical engineering investigations on the recovery of fruit flavors and other products from apples and from other eastern fruits. To develop methods for recovering the fragrant constituents of fruits now lost in processing and restoring them to the fruit products.

RESEARCH PROJECT RRL-4-(3)-A-1 - ANALYTICAL CHEMICAL INVESTIGATIONS

RRL-4-(3)-A-1-1 - Research analysis investigations. To perform routine and specialized chemical analyses on apples and other fruits and their derived products, and to develop new and improved methods of analysis when required.

RESEARCH PROJECT RRL-4-(3)-A-2 - PHYSICAL CHEMICAL INVESTIGATIONS

RRL-4-(3)-A-2-1 - Miscellaneous physical chemical investigations. To apply specialized methods of physical chemistry to the chemical and technological problems arising in the development of new and extended uses for apples and other fruits.

RRL-4-(3)-A-2-4 - Identification and control of chemical and physical factors responsible for textural defects in the tissue of processed apples. To determine, through basic physical chemical studies, the causes for change in tissue firmness or texture on processing apples and other fruits, and to develop practical means of controlling the texture in processing.

RESEARCH PROJECT RRL-4-(3)-A-3 - PHYSICAL INVESTIGATIONS

RRL-4-(3)-A-3-1 - Miscellaneous physical investigations. To apply specialized methods of physics to the chemical and technological problems arising in the development of new and extended uses for apples and other fruits.

RESEARCH PROJECT RRL-4-(3)-OD-1 - DEVELOPMENT STUDIES ON THE UTILIZATION OF APPLES AND OTHER FRUITS

RRL-4-(3)-OD-1-1 - Technical development surveys relating to the industrial utilization of apples and other fruits. New developments in the laboratory are brought to the attention of outside interested parties, and problems and questions of the latter are brought back to the laboratory.

RRL-4-(3)-OD-1-2 - Market surveys relative to, and industrial developments on, processes for the utilization of apple products. To determine the market possibilities of various types of apple products and processes developed in the laboratory, to promote their industrial adoption, and to provide manufacturing and cost data.

C. History and Evolution of This Work

In some years apples are produced in excess of normal requirements, and in every year a part of the crop is not suited to the fresh fruit market. Our object has therefore been to find more outlets for this fruit and to develop new products from it and from its by-products. Both food and non-food uses have been sought. At first, efforts were largely confined to processed juice. Later special pectins from apple pomace were developed. Methods were found for firming summer apples to make them suitable for canning. Later, work was directed to the recovery of the volatile fraction from fruit juices in a concentrated form termed essence. It can be recovered during certain processing operations, or it can be prepared directly from juice. The Bureau has sponsored three conferences of the fruit processing industry. To facilitate the adoption of processes and products developed in the laboratory, active liaison has been maintained with processors, growers, and co-operatives. Thus Bureau knowledge is taken to them, and their problems and views brought back to the Bureau. This relation was especially useful in the commercial development of fruit essence.

D. Funds--Annual Expenditures

The average for 1941 through 1945 was $80,000; for 1946 through 1949, $208,000. The expenditure for 1950 was $133,000, apportioned as follows: B-1, $36,600; A-1, $12,000; A-2, $13,000; A-3, $13,300, E-1, $47,300; OD-1, $10,800.

E. Examples of Outstanding Accomplishments

RESEARCH PROJECT RRL-4-(3)-B-1

Firming slices of those varieties of apples which are too soft for canning or which mush too much in a pie was accomplished by dipping the slices in a solution of a calcium salt. Summer apples of high flavor, and certain soft winter varieties, are now being canned and frozen for the first time. Three companies are known to be using the process.

Apple sirup. In 1942 a process was announced for making an industrial sirup from low grade apples. During the next five years nine million pounds of it were made from 900,000 bushels of apples, with a value of $1,530,000 for the sirup at the OPA price ceiling. It was used largely as a war-time glycerine substitute in tobacco products.

Apple juice concentrate is distinct from apple sirup in that it retains the original acidity. In addition to its conventional use in mince meat and jellies, a new use is as a modifier of milk in infant feeding. It produces a softer and hence more digestible curd in the stomach. This new use will account for about 500,000 bushels of apples annually.

Improved apple juice. After making surveys of commercial apple juice for four different seasons, it became obvious that in general the same manufacturers made good juice all the time or poor juice all the time. By concentrating on the negative aspects - the factors which make for poor juice - the Bureau found that unripe fruit, spoiled fruit and unsanitary housekeeping are the principal causes of low quality processed juice. As a result of compaigning to correct these conditions, there is gradual improvement in the quality of commercial juice, and this should help apple juice to improve its position among the other fruit juices.

Constituents of apple essence. A chemical study of the volatiles of apple juice revealed 26 different substances, including aldehydes, alcohols and esters. Since the total of these materials in the juice is only 50 parts per million, their isolation and identification was an outstanding example of chemical skill. It is obvious that a synthetic mixture of these items will not likely be a competitor of the natural essence. The recovery of the latter is aided materially by this knowledge of the constituents. Flavor manufacturers have made use of this information in the preparation of their natural flavoring products.

The production of low-ester pectin from apple pomace by an enzyme method has been perfected. These pectins make possible new types of jams, aspics and salads.

RESEARCH PROJECT RRL-4-(3)-E-1

Fruit essence. A process and equipment were developed for recovering in highly concentrated form the fragrant constituents of fresh apple juice. The juice is simultaneously pasteurized without altering its flavor. Modifications for Concord grape juice were also worked out. Approximately fifty companies have installed apple essence recovery units. One company has three units, and another, in Canada, a capacity of 5,000,000 gallons of apple juice annually. In the first year of production (1949-50) at least 5000 gallons of essence worth $5.00 a gallon, were produced from 5000 tons of apples. The stripped juice is used for vinegar, wine and concentrated apple juice production. Industry has also adapted the essence process to cherries, peaches, blackberries, strawberries, pineapples and apricots; and experimentally from orange, tomato, raspberry, damson plum and quince. Essences are used commercially in beverages, flavor extracts, candy, and frozen concentrates.

Fruit juice concentrates. One of the most important uses of fruit essences is to restore aroma to juice concentrates. Such products are called full-flavor concentrates and on the addition of 5 parts of water they give a beverage hard to tell from the fresh juices. These concentrates do not require freezing but may be kept under ordinary refrigerator conditions. An apple concentrate is now added to milk to give a beverage of modified flavor. Methods have also been developed for preparing full-flavor frozen concentrates from both apple and grape juices. These can be diluted in the home with 3 parts of water to give the equivalent of a fresh juice in the same way that frozen concentrated orange juice is now used.

RESEARCH PROJECT RRL-4-(3)-A-1

Analytical service and research. The accomplishments under this project were of a service and research nature which contributed materially to work in progress on other projects. Thousands of analyses were made on apples and their derived products for various constituents of importance. For some of these the development of new and improved methods was required. Examples were the determination of unaltered pectin in apples and the determination of small amounts of alcohol in apple essence.

RESEARCH PROJECT RRL-4-(3)-A-2

Physical chemical service and research. The accomplishments under this project were of a research nature concerned with basic studies on the causes for change in tissue firmness that occur when apples are processed, and the development of practical means of controlling the firmness on processing. The information contributed to the accomplishment under Research Project RRL-4-(3)-B-1, "Firming slices ....of apples..."

Basic knowledge of apple pectin extended. Pectin, a by-product of the apple processing industry, has been used almost exclusively as a jellying agent in foods such as jams and marmalades. Modification of the pectin chemically or by means of enzymes offers the possibility of a much wider field of application in the food, pharmaceutical and other industries. Under this project an investigation has been made of the ultimate units of pectin, the molecules, before, during and after a variety of modification processes. This has shown how and why the properties of apple pectin are altered by changes in the conditions of modification, and is thus valuable in specifying what conditions are required for producing modified pectins with particular qualities for particular applications. Use has been made of the basic knowledge acquired under this project in the development and commercial trials of "low methoxyl pectinate films" for packaging, described under Project RRL-3-11, "Utilization investigations on fruits of the Western Region."

RESEARCH PROJECT RRL-4-(3)-A-3

Physical service and research. The accomplishments under this project were of a research and service nature dealing with the development of specialized physical methods and their application to work in progress under other projects. For example, spectroscopic methods were applied to the precise measurement of the important quality of color in: (a) apple juice, prepared in the laboratory and subjected to a variety of commercial storage conditions; and (b) red tart cherries, in the effort to correlate maturity, soluble solids and color with the "drained weight" or yield of cherries after commercial canning.

A differential refractometer, an optical instrument for analysis of small quantities of substances in solution, was successfully adapted to the determination of less than 0.2 percent of ethyl alcohol. It was used in connection with apple essence development.

RESEARCH PROJECT RRL-4-(3)-OD-1

Promotional efforts under this project were directly responsible for the quick adoption of the apple sirup process and of the commercial development of fruit essences. Furthermore, industrial problems concerning these products were brought back to the laboratory for solution.

F. Some Additional Work Needed

Composition of fruits. Some 10 percent of the dry matter of fruits is of unknown composition. What are these substances? What relation do they bear to storage quality of fruit, to stability of juice concentrates, to possible new uses? Are any of them valuable in their own right for drugs or for industrial use? Ultimately these questions should be answered.

Fruit juice concentrates. Following the lead of frozen concentrated orange juice, satisfactory apple and grape frozen concentrates have been developed. Many factors, however, still remain to be explored - among others, the influence of variety, the role of microorganisms, conditions of concentration, addition of essence or of fresh juice to the concentrate. The study needs to be extended to other fruits as well. The high density, self-preserving, full flavored concentrate should be perfected, and the behavior of all juice concentrates on long storage at various temperatures should be studied. New uses for the stripped juices after essence recovery must be developed so that the essence will not have to bear the full cost. Solution of these problems should result in the utilization of a large amount of fruit, which is the Bureau's goal.

Industrial uses for pectin must be found. Pectin is the main unique constituent of pomace. Finding industrial uses for it would be finding uses for the pomace now wasted. Such pectin could probably be in a crude, inedible form.

Powdered fruit juices. Concentrated fruit juices are successful because of the reduction of bulk and weight. One step further in this direction would be preparation of the juices in powder form, as in powdered or soluble coffee. Theoretically this can be done, and still have the powder embody all the volatile flavor fraction. The means for doing this must be worked out.

Valuable fruit aromas are now lost during the vacuum processing of fruit and fruit juices to produce concentrates, jams and jellies. Engineering studies should be made to determine how these aromas can be captured in essence form either to enhance the taste and aroma of the products from which they came or for use in making other food products.

NEW AND IMPROVED USES FOR DECIDUOUS FRUITS, ESPECIALLY TO PREVENT WASTE

(BAIC - RM:a-125 - Federal-State- RMA Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To develop new uses for, and improve existing products from, deciduous fruits (especially fruits other than apples) and their wastes. The present work includes the development of commercially feasible methods for preparation of fruit-flavor essences, concentrated fruit juices, purees, and nectars. An effort is made to preserve or incorporate in these products the full, natural, aromatic flavor of the fresh fruits. Fundamental work is also under way on the identity and amounts of important fruit constituents. Another activity is the recovery of edible byproducts from fruit-cannery residues such as cores and peels.

B. Currently Active Line Projects

RM:a-125-1 - Recovery of sugar from pear-cannery waste. To develop an economical process for recovering sugars from pear-canning waste and converting such sugars into a purified sirup suitable for use in sweetening canned pears. Cooperative work is being conducted with an apple growers association in Oregon.

RM:a-125-2 - Biochemistry of the processing of sour cherries. To develop an understanding of the chemistry and physics involved in the various steps of processing sour cherries, especially cherries that have been grown under certain spray treatments.

RM:a-125-3(c) - Improvement of the quality of processed sour cherries. To determine the effects of various fungicidal sprays and of various soaking and cooling pre-processing treatments on the quality of canned and frozen sour cherries, under a contract with the Michigan Agricultural Experiment Station.

RM:a-125-4(c) - Processing studies on eastern-grown freestone peaches. To develop new and improved procedures for ripening and processing eastern-grown freestone peaches, under a contract with the Michigan Agricultural Experiment Station.

*Low-sugar fruit spreads and gelled desserts. To develop from low-pectin fruits (strawberries, peaches, cherries, and black raspberries) a new type of spread by employing the formation of calcium pectinate to thicken the product.

*Chemical engineering investigations on new uses of deciduous fruits. To conduct pilot-plant-scale research on the preparation of essences from fruit juices, or from residues such as pomace, or from the vapors evolved during fruit processing.

*Line of work for which no symbol has yet been assigned.

*Volatile and nonvolatile concentrates from western-grown deciduous fruits. To develop new and improved processing methods and equipment for the recovery and concentration of volatile fruit flavors (essences) and for the preparation of new products such as full-flavored concentrated purees or juices through removal of substantial amounts of water and fortification with the recovered essence. Concentration of such products results in appreciable savings in packaging, storage, and transportation costs; recovery and addition of the volatile flavors to the fruit concentrates or to other food products results in improved flavor and greater acceptability of the products by the consumer.

C. History and Evolution of This Work

This project was started in 1948. It was intended to extend to the soft fruits the processes developed for apples in work carried out under regular funds.

The growing surpluses of some fruits and the difficulty of marketing perishable fruits at great distances led the Department to carry on additional research on production of fruit concentrates and on utilization of fruit byproducts. The current studies aim in part to develop a process for recovering the sugars from pear waste in the form of a clear, colorless juice suitable for use as a sirup base in preparing canned pears. Such a process would permit the canner to recover a relatively valuable product from the waste. Other phases of the research deal with the study of processing problems by the Michigan Agricultural Experiment Station under contracts (one on freestone peaches and one on cherries) and - in cooperation with a preserves manufacturer - with the design, construction, and testing of apparatus for the recovery of vapors evolved during the commercial open-kettle cooking of fruits.

D. Funds - Annual Expenditures

The annual expenditures have been, for 1948, $41,000; for 1949, $55,000; and for 1950, $89,000.

E. Examples of Outstanding Accomplishments

Intensity of volatile flavor in several varieties of strawberries has been determined. This information will be useful to growers and processors in selecting strawberry varieties suitable for use in preparing essences and full-flavored concentrates.

A practical process has been developed for recovering the sugars from pear-canning waste in the form of sirup useful to pear canners. This process is now under development on a pilot-plant scale in a cooperative pear cannery. The use of such sirup would reduce the sugar requirement by about one-third.

New equipment for fruit essence recovery has been developed which results in little alteration of the natural fruit flavor and minimizes the development of undesirable cooked flavors. This equipment will be especially applicable to fruits that are heat-sensitive or difficult to process because of plugging or fouling of conventional apple-processing equipment.

*Line of work for which no symbol has yet been assigned.

New and improved methods of preparing frozen apple-juice concentrate have been developed and compared with existing procedures now in use. It has been shown that the low evaporating temperatures and expensive high-vacuum equipment used by the frozen-orange-juice-concentrate industry are not needed for preparing frozen-apple-juice concentrate. As a result of these studies, several commercial producers of frozen-apple-juice concentrate are considering modification of their preparation procedures in order to incorporate these new developments. Such changes will result in an improved product and may substantially reduce processing costs.

Apple-juice concentrate suitable for emergency use. Storage stability of a four-fold apple-juice concentrate, heat processed and stored at room temperature, has been found equal to that of conventional apple juice of cider. This new concentrate may prove to be useful to the armed services.

F. Some Additional Work Needed

Modification of processing methods for fruits grown in different regions of the United States. Further work is needed on modification of existing processing procedures for essence recovery and preparation of full-flavored concentrates to take into account the peculiarities of certain varieties of fruits and to fit the processing schemes into the different growing and harvesting practices existing in different regions of the United States.

Development of new and simpler methods of preparing fruit concentrates. Improvement of the storage stability of the products and further reduction of processing costs would extend the utilization of surplus or perishable fruits. Development of such methods would be of particular significance to the armed forces.

Processing and preparation for marketing of certain tropical fruits. In cooperation with the Hawaiian Agricultural Experiment Station new or improved methods should be developed for the manufacture of purees, nectars, and other products from tropical fruits, especially papaya and guava, in order to promote greater distribution of these fruits in the continental United States and elsewhere.

Improvement of methods for the preparation of canned fruit juices to prevent color changes and cloud formation in storage. This applies especially to highly colored fruits such as strawberries, cranberries, or grapes.

Improvement of processing methods of tree nuts to simplify blanching procedures and to improve the flavor of processed nuts and nut products.

Improvement of processing methods of small fruits, particularly cranberries, blueberries, blackberries, and raspberries, in order to produce canned products more attractive in texture, color, and flavor.

Development of new and improved uses for wastes resulting from the processing of deciduous fruits. In addition to waste from the pear-canning operation, residues from the processing of grapes, peaches, apricots, apples, and berries present a serious disposal problem or a nonprofitable byproduct outlet. Research is needed to provide increasingly profitable uses for such residues.

Essence recovery from vacuum kettles, in contrast to that from open kettles, should be developed in order to keep abreast of changes in the fruit-preserves industry.

RESEARCH CONTRACT - EQUIPMENT FOR RECOVERY OF JUICE FROM PEAR AND OTHER FRUIT PROCESSING WASTES

(BAIC - RM:a-182 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

The objective of this project is the design and construction of a pilot-plant model of a practical, continuous-type press for recovery of juice from pears and other fruits and their processing wastes. The single line of work authorized by this work project has not been organized on a line project. The project is being carried out under a research contract with an engineering firm in Berkeley, Calif., which calls for the design and construction of a continuous-type press for fruit wastes.

B. Currently Active Line Projects

None

C. History and Evolution of This Work

Fruit-processing plants and press manufacturers have attempted for many years to develop a practical continuous press for the recovery of juice from processing wastes and from fruit not suitable for processing or sale in the fresh-fruit market. At the time this contract was awarded in 1948, no commercially practical method was known for accomplishing this separation efficiently in a continuous operation. Since the initiation of the contract, other studies within the Bureau have indicated methods for effecting mechanical separation of fruit juices from processing wastes that have been subjected to a preliminary chemical treatment. The importance of the press development may therefore center largely on the primary production of fruit juices where no preliminary chemical treatment is permissible.

D. Funds - Annual Expenditures

The sum of $40,000 was obligated for this contract in the fiscal year 1948. During the 2 years the contract was awarded, progress has been such that all but the final partial payment to the contractor has been made.

E. Examples of Outstanding Accomplishments

A pilot plant model of the press has been completed and is ready for testing.

F. Some Additional Work Needed

Extensive testing of the new press will be necessary in order to evaluate its potentialities from the standpoint of application of the design principles in the construction of commercial units. Work is planned on both fruit and vegetable wastes and on the primary production of fruit juices with a view to developing designs for commercial units that will avoid the high labor cost involved in the use of present rack-and-frame hydraulic presses. It is anticipated that this will require between 1 and 2 years of processing studies on various fruits, with minor alterations to the press being made as found necessary to improve the operating characteristics. If major changes in press design are found to be necessary, a longer time may be needed before the design basis is established for a commercial press.

STUDY OF FUNDAMENTAL CHARACTERISTICS OF FRUIT TANNINS TO AVOID DARKENING AND OFF-FLAVOR DEVELOPMENT IN PREPARATION AND STORAGE OF PROCESSED FRUIT

(BAIC - RM:a-505 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

To identify the chemical substances in fruits that are responsible for the formation of objectionable brown color and the deterioration in flavor when certain fruits are sliced or cut and exposed to air, as in preparing them for dehydration, freezing or canning. The work involves extracting these substances from the fruit, separating and purifying them, determining their chemical constitution and properties. With the basic information so gained, methods will be sought for the prevention of browning during manufacture or storage of processed fruits.

B. Currently Active Line Projects

RM:a-505-1 - Identification of polyhydroxy-benzene constituents (tannins) isolated from peaches. To isolate, purify, and establish the chemical constitution and properties of substances that cause browning in peaches; to develop effective methods for prevention of browning in peaches; and to devise tests for measuring the browning tendency of different varieties of peaches. This information is needed by peach breeders and fruit processors.

C. History and Evolution of This Work

The work on this problem was at first confined to the development of empirical methods for the prevention of browning in fruits. Certain chemical treatments were formulated, and some are still being used commercially, but the treatments themselves may result in undesirable flavor, or their effectiveness may be of only limited duration. Later it was established that browning occurs through the combined action of air (oxygen) and certain fruit catalysts (enzymes) on fruit constituents broadly classified as tannins. The properties of the enzymes and of the tannins are not thoroughly known, and it is the lack of this knowledge that hampers further development of effective methods for browning prevention. Special emphasis is therefore being given to fundamental investigations on the tannins (a large group of complex compounds) to serve as groundwork for practical solution of the discoloration problem. The impetus for this work comes in large measure from the fruit-freezing industry, where the problem is most acute. Work on this project was started in the summer of 1949.

D. Funds--Annual Expenditures

The amount expended on this project has been approximately $14,000 during fiscal year 1950 which marked the beginning of this project.

E. Examples of Outstanding Accomplishments

Since this project was started so recently, nothing outstanding has been accomplished on it thus far.

F. Some Additional Work Needed

Extension of the fundamental work. The outlined research on fruit tannins now limited to peaches should be extended to include other commercially important fruits such as apples, apricots and pears.

FUNDAMENTAL STUDY OF FACTORS THAT INFLUENCE TEXTURE IN PROCESSED BERRIES AS A MEANS OF DEVELOPING IMPROVED PROCESSING TECHNIQUES

(BAIC - RM:a-519 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

To investigate the causes of the deterioration in texture of berries observed after processing treatments such as canning and freezing preservation. Among the specific textural problems being investigated are: (a) excessively soft and mushy texture and breaking apart into fragments of certain commercial varieties of red raspberries after canning and transportation; (b) clumping of blueberries during canning, leading to a large percentage of broken berries and loose skins as the clump is broken up for use; (c) undesirably soft and mushy texture of strawberries after freezing and thawing, accompanied by excessive bleeding or "drip"; (d) undesirable variation in texture of certain lots of preserves or jams prepared from berries, particularly Boysenberries and blackberries.

Fundamental research is in progress on the kinds of pectin and pectic enzymes that may exist in berries and on the action of berry enzymes upon berry pectins under various conditions commonly used in processing.

B. Currently Active Line Projects

RM:a-519-1-c - Identification and control of chemical and physical factors responsible for textural defects in processed berries. To determine the factors that control texture in processed berries, with emphasis on the role of pectin chemistry. This involves a study of the chemical constituents of berries, with particular stress on pectins and pectic enzymes, and the use of the microscope to determine the tissue structure of the berries. Practical application of the fundamental information gained is to be made in controlled processing studies by a cooperating State agricultural experiment station.

C. History and Evolution of This Work

Problems of texture are among the most persistent of those encountered in berry processing. Such problems are assuming increased importance now since expansion of markets for berries is dependent in large measure on the availability of processed products of excellent texture as well as of attractive flavor and color. It has been known for many years that pectin (a chemical widely distributed in fruits and vegetables) plays an important role in the texture changes which fruits and vegetables undergo during maturation, storage, and processing. Many of these changes have been attributed to the action of certain enzymes upon pectin. Recent work in the Department resulted in the isolation of two important pectic enzymes (pectinesterase and polygalacturonase), and determination of their modes of action helped to solve a number of important food-processing problems. This work suggested the application of similar techniques to the problems of berry-texture deterioration. The work on berries was instigated by several State agricultural experiment stations and berry growers' associations and was started during the Summer of 1949. Western Washington Agricultural Experiment Station agreed to supply samples of berries for the fundamental research and to conduct controlled processing studies.

D. Funds--Annual Expenditures

Approximately $13,000 was expended in fiscal year 1950 which was the first for this project.

E. Examples of Outstanding Accomplishments

Prevention of clumping in canned blueberries. A simple and effective means of preventing the clumping of canned blueberries has been found. This involves the use of an agitating cooler which keeps the freshly canned berries in constant motion until they are cooled to around 100°F. Once this is accomplished, the berries are free-flowing and have no tendency to stick together during storage.

Discovery in berries of an enzyme capable of acting on pectin. Substantial amounts of the enzyme pectineasterase have been found in both raspberries and blueberries. This enzyme may prove to be of importance in modifying the texture of berries during processing and storage.

F. Some Additional Work Needed

Texture problems caused by hemicelluloses other than pectin. To examine berries for (hemicelluloses) other than pectin and for enzymes that attack them and to relate the information gained to textural changes in berries.

DEVELOPMENT OF IMPROVED INSTRUMENTS FOR RAPID MEASUREMENT OF MOISTURE AND COLOR OF FRUITS, VEGETABLES, AND NUTS, RAW AND DEHYDRATED

(BAIC - RM:a-520 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

To develop instruments that will satisfactorily determine the moisture content and related characteristics of raw, dried, and processed fruits, vegetables, and nuts, and instruments that will measure the color of fruits and vegetables.

B. Currently Active Line Projects

RM:a-520-1 - Development of new instruments for rapid measurement of moisture in fruits, vegetables, and nuts. To develop new instruments for rapid objective measurement of the water content of fruits, vegetables, and nuts, in the range of 20 percent to 90 percent, which is beyond the scope of presently available electrical instruments for moisture determination.

RM:a-520-2 - Development of new instruments for rapid measurement of color by reflectance in fruits, vegetables, and nuts. To develop new instruments for measuring specific color characteristics in fruits, vegetables, and nuts. A simple, portable color-measuring instrument for field use in the selection of vegetables and fruits of proper maturity for processing is now under development.

C. History and Evolution of This Work

It has long been recognized that quick and accurate methods of determining moisture are of primary importance in the selection of agricultural products for specific uses, control of processing and stabilizing for storage. The oven-drying, distillation, and titration methods were too slow and these were supplanted by several kinds of electrical methods for some materials. The electrical methods, although faster than the earlier methods, were only useful for materials of low moisture content.

It has also been recognized that the color of fruits and vegetables and the changes in color during processing and storage are major factors in consumer acceptance of these foods. No satisfactory instrument for measuring color rapidly was available.

In view of the need for instruments to rapidly measure moisture and color of agricultural products, work was started under this project in the latter part of 1949.

D. Funds--Annual Expenditures

During fiscal year 1950, which was the first year of work under the project, expenditures of about $14,000 were made.

E. Examples of Outstanding Accomplishments

A new magnetic moisture meter has been developed to the laboratory stage. It is based on the recently discovered principle of "nuclear inductance", which depends on the magnetic properties of the hydrogen nucleus. This instrument is particularly effective over the higher range of moistures or where the electric moisture meters failed. A paper discussing the principle upon which this instrument is based has been published.

F. Some Additional Work Needed

Application of moisture and color meters to field use and processing operations. When the magnetic moisture meter and portable color meter have been perfected as laboratory instruments, their adaptation to field use and processing operations for fruit, vegetables, nuts and other commodities should follow.

The development of a moisture-measuring instrument for use with dehydrated alfalfa and egg powders should also be undertaken. These products must be of very low moisture contents to prevent deterioration in storage, and a special instrument would be required to measure moisture content in such a low range.

CROSS REFERENCES - UTILIZATION

For additional information especially pertinent to the subjects reported on in this chapter see also:

BAIC - b-8 - Chapter 12, utilization studies on fruits, vegetables, etc. of the West.
BAIC - b-9 - Chapter 3, microbiological research in freezing fruits and fruit juices.
BAIC - RRL-5-3 - Chapter 38, utilization of fruit and nut residues.
BAIC - BAI, BDI, RM:a-307 - Chapter 14, fruit byproducts as feed.
BHNHE - RM;a-12 and b-1-16 - Chapter 39, food utilization and preparation.
BHNHE - RM:-13 - Chapter 29, family food consumption.
BHNHE - RM:a-345, b-1-17 and b-2-2 - Chapter 29, distribution of nutrients in foods and nutritive value.

PRICE, SUPPLY AND CONSUMPTION ANALYSIS FOR FARM PRODUCTS (FRUITS AND TREE NUTS)

(BAE - A-2-7 - Federal-Regular Funds)

(Related work in these projects is discussed in other commodity chapters and in Chapter 27, "Prices and Income.")

A. Purpose and Nature of Current Work

To (1) appraise the current and prospective economic position of fruits and tree nuts and (2) make the results available through regular publications and on special request to farmers, Government agencies and the general public.

B. Currently Active Line Projects

A-2-7-7 - Price, supply and consumption analysis for fruit. To (1) appraise the current and prospective economic position of fruits and tree nuts; (2) carry on the statistical and analytical work necessary thereto, and (3) make the results available through regular publications and on special requests, to farmers, Government agencies and the general public. The Fruit Situation is prepared and issued under this line project.

C. History and Evolution of This Work

(See this topic under project A-2-7 in Chapter 27, "Prices and Income.")

D. Funds--Annual Expenditures

Expenditures on this work during the 1950 fiscal year (all on regular budget) amounted to about $15,000.

E. Examples of Outstanding Accomplishments

Government programs aided. During the 1930's many special statistical materials and analyses were provided for use in Government programs, particularly marketing agreements under the Agricultural Adjustment Administration.

Basic and war facts on citrus compiled and published. Basic data on world citrus production and trade were assembled in a special report "The World Citrus Situation" (1939). A report "Citrus Fruit During World War II" was released in 1950, containing basic information on the programs and regulations affecting the production, movement and prices of citrus fruit during the last war.

A basic statistical handbook on fruits, "Production and Consumption of Fruits, 1909-40," was published in 1943.

F. Additional Work Needed

Development of improved forecasting relationships are needed for many of the individual fruit items.

Further statistical analysis is needed to discover competitive relationships between the fresh, canned and frozen forms of the various fruits.

Economic significance of relationships between the product weight of processed fruits and fruit juices and the weight of the raw products should be explored.

Further improvement on the long-time historical series of per capita fruit consumption is desirable for the purpose of improving analysis of long-time trends.

CONSUMER PREFERENCE RESEARCH (DECIDUOUS FRUITS)

(BAE-OES-BHNHE-RMA-c-31-Federal-State-RMA Funds)

(Related consumer preference research by BAE on other commodities is discussed in other commodity chapters. Consumer preference research conducted by BHNHE and OES, as well as line projects of BAE involving more than one commodity, are discussed in the general statement on consumer preference research in Chapter 26, "Economics of Marketing").

A. Purpose and Nature of Current Work

To study (1) consumers' information about and (2) preferences among different deciduous fruits. Current work is designed especially to find out the extent to which competition from other fruits is responsible for the decline in per capita consumption of apples during the last decade and some of the reasons for shifts in consumption from apples to other fruits; to find out how small apples, for which most of the former export market has disappeared, can be utilized most economically in the United States; and to find out whether consumers know how to ripen winter pears satisfactorily after they have bought them, or whether the pears should be sold only after they are ripe. Such research should ultimately improve the net incomes of growers, and give consumers a product more satisfactory to them.

B. Currently Active Line Project

RM:c-31.18 - Consumer preferences for apples and winter pears To provide information on competition among fruits, purchase of apples in relation to use, home storage of apples and pears, sale of small apples, etc.

C. History and Evolution of This Work

The Department was authorized to make studies of this general type by the Research and Marketing Act of 1946, and this line project started in December 1948 was approved by the RMA Deciduous Fruit Advisory Committee.

D. Funds--Annual Expenditures

Consumer preference research on deciduous fruits undertaken by BAE during the fiscal year 1950 cost $6,500 from RMA funds.

E. Examples of Outstanding Accomplishments

Supplying of consumer preference information to fill long-standing gaps. Retail store experiments carried on by some State colleges and certain work in the Department regarding costs and margins in respect to apples will be complemented by this study of consumer preferences on a national scale. No other consumer preference work of this type has yet been done. It will extend to apples and winter pears the survey techniques which have been so successful with other commodities. A few findings are that 80 percent of all homemakers have some one favorite fruit. One-third of these prefer apples, one-third favor oranges and the remaining third have preferences scattered among a large list of other deciduous and citrus fruits. Chief reason for preferring apples is the versatility of use to which they can be put. Preferred varieties are the Delicious for eating raw, the Jonathan for general use and the Greening for cooking. Many other findings are contained in the report which is now in press as "Consumer Preferences for Apples and Winter Pears," Agricultural Information Bulletin No. 19, Wash. D.C., 1950. Since the report has not yet been released, nothing can be said about the use to which the findings will be put.

F. Some Additional Work Needed

Expansion to cover other commodities and other uses. Patterns of preference and use among commercial bakers and other industrial consumers of fruit and fruit products should provide valuable information for the deciduous-fruit producers and the associated industries. Furthermore, the present work on apples and pears could well be extended to cover other deciduous fruits, in both fresh and processed stage and for both household and industrial consumers.

MEASUREMENT OF COSTS AND MARGINS IN MARKETING FARM PRODUCTS--(DECIDUOUS FRUITS)

(BAE-OES - RM-c - 163 - Federal-State - RMA Funds)

(Related work in this project is discussed in other commodity chapters and in Chapter 26, "Economics of Marketing.")

A. Purpose and Nature of Current Work

To measure costs and margins in marketing deciduous fruits and to analyze factors affecting margins, thereby to provide the basis for suggesting ways and means of bringing about more efficient and orderly marketing, and reducing the price spread between the producer and the consumer.

B. Currently Active Line Projects

RM:c-163.3 - Shenandoah Valley apple study. State Cooperation A study into the efficiency and adequacy of facilities for marketing Shenandoah Valley apples.

RM:c-163.4 - Studies into the efficiency of performing specific marketing services. State Cooperation A study of the efficiencies of labor utilization in apple and pear packing and processing plants in Oregon, Washington, and California; relationship of labor requirements to plant lay-out, flow of materials, and other factors that have a bearing on the efficiency of labor use for the plant operations.

RM:c-163.10a - A study for developing adequate methods and techniques for the handling of bananas shipped from Puerto Rico to the Continental United States. Puerto Rico Cooperation A study of handling methods, costs, and margins in marketing Puerto Rican grown bananas in the United States.

RM:c-163.12 - Marketing margins for selected processed fruits and vegetables (Deciduous Fruits) The primary objective of this study is measurement of average marketing spreads existing between growers of raw produce and consumers of the same commodities in the canned or frozen form. Items included are canned cling peaches, freestone peaches, and Bartlett pears, and frozen peaches and strawberries. The initial report relating to margins above the processor level has been published. A breakdown of processing costs and grower returns is being prepared as a sequence to the first release on the project.

RM:c-163.13 - Farm-to-retail margins at different levels of trade for Appalachian apples sold in specified cities. State Cooperation A study of packing, cold storage, selling, and hauling costs involved in moving Appalachian apples into selected eastern markets.

RM:c-163.16 - Costs and margins study on Indiana apples. State Cooperation A study of prices paid and received by handlers and service agencies engaged in marketing Indiana apples; determination of cost components and the relationship of specific costs to specific services in moving apples from the farms to the consumers in Indiana.

C. History and Evolution of This Work

The Department was directed to make studies of this general type by the Research and Marketing Act of 1946, and these specific line projects were recommended by the Deciduous Fruit Advisory Committee.

D. Funds--Annual Expenditures

The cost of RMA projects on costs and margins in marketing deciduous fruits undertaken by the Bureau of Agricultural Economics during the fiscal year 1950 was $39,700 and $7,600 in 1949. (See "Measurements of Costs and Margins of Marketing Farm Products" in Chapter 26, "Economics of Marketing.")

E. Example of Outstanding Accomplishments

The grower's share of the consumer's dollar spent for Washington Delicious apples in Chicago was 15.7 cents in December 1947, 35.4 cents in December 1948, and 7.3 cents in December 1949. Variations in "on-tree" prices for Washington Delicious apples were not reflected in proportionate changes in Chicago retail prices for the fruit during October, November, and December of the 1947, 1948, and 1949 seasons. Analysis of data supplementing the 1947-48 study of farm-to-retail margins for Washington apples shows that in certain instances spreads between prices received by the grower and prices paid by consumers narrowed when farm prices rose and widened when they declined.

F. Some Additional Work Needed

A continuation of a selected group of studies designed to measure marketing margins and costs, development of a limited amount of research into sampling techniques, and the initiation of a pilot study of managerial policies and practices that affect the operating efficiency of fruit and vegetable processing plants.

REGIONAL MARKETING RESEARCH ON FRUITS AND VEGETABLES (OTHER THAN CITRUS AND POTATOES). -(DECIDUOUS FRUITS)

RM:b-165 BAE, BEPQ, BHNHE, BPISAE, PMA FEDERAL-STATE RMA FUNDS

For work in cooperation with States under Regional projects. Nos. NCM-2, NEM-2, WM-2, WM-3, SM-4, WM-8, NEM-3, SM-3, see Chapter 39.

(Related work in this project is discussed in Chapter 14, "Vegetables").

A. Purpose and Nature of Current Work

To improve the marketing of deciduous fruits (other than citrus and potatoes) in the regions. This includes segregating the marketing factors that affect demand and consumption and working out ways in which consumption might be increased; ascertaining consumer preference in terms of kinds and qualities and methods of packaging and handling, with a view to better adapting production and marketing policies and practices to the wishes of consumers; and improving the efficiency and reducing the costs of marketing through the various methods, channels and processes, to the end that consumers might be benefited and returns to growers increased.

B. Currently Active Line Projects

RM:b-165.2 Investigation of quality of fresh fruits moving through wholesale and retail markets to consumers. To determine the degree of different types of deterioration in fruits found at market centers in the North Central States. To determine palatability and cooking quality of unspoiled portions from deteriorating samples.

RM:b-165.5 Determine responsibility for bruising of apples and develop means of delivering apples of improved quality to consumers at minimum costs. To determine when and how bruising occurs and develop means of preventing it so as to improve the market appearance and quality.

RM:b-165.6 Influence of consumer acceptance on the marketing of midwestern apples. To discover the marketing practices and other conditions necessary to maximize the sale of and returns from apples in retail stores. Comparisons of price and quality will be made for apples and for selected competing commodities in a selected sample of retail stores in Detroit.

RM:b-165.8 Improving the marketing of Western deciduous tree fruits. A controlled retail-store experiment is being conducted in 12 stores in Milwaukee to determine consumer acceptance of peaches that have varying degrees of ripeness.

C. History and Evolution of this work

See Chapter 14 on "Vegetables".

D. Funds - Annual Expenditures

The following budget includes both fruits and vegetables under RM:b-165:

(See Chapter 14 on "Vegetables".)

Agency	1948	1949	1950
FCA	$1,100	$2,200	$3,700
BEPQ	100	---	---
BHNHE	1,100	2,700	3,200
BAE	11,300	12,800	18,000
PMA	9,700	7,300	16,500
BPISAE	4,200	7,600	16,100
TOTAL	$27,500	$32,600	$57,500

E. Examples of Accomplishments

Three-fourths or more of all consumer purchases of fresh peaches were of ripe or firm ripe fruit. Many consumers paid 6 cents a pound premium for ripe peaches over firm peaches. Proportions of the various maturities of the peaches received at the retail stores in this study differed materially from proportions desired by consumers. These findings were obtained from selected stores in Kansas City, Oklahoma City, Minneapolis, and Milwaukee, during the 1949 peach-marketing season. Results of cooperative study were published as "Consumer Demand for Peaches of Varying Stages of Maturity", by the Utah Agricultural Experiment Station.

Apple bruising studies showed that more bruising occurred during handling from the refrigerator car to the retail store than during loading of cars or in transcontinental shipment. Factors found to contribute to bruising during packing were operation of sizers at high speeds, use of towel instead of air driers and use of unlined sorting rollers. Use of compressed pulp trays for packing gave 3 times more sound apples than were obtained in the standard box.

F. Some Additional Work Needed

As this project originates with Agricultural Experiment Stations, the lines of work to receive attention will be selected by the Technical Committee of workers from the Agricultural Experiment Stations in consultation with representatives of Federal agencies. The Federal agencies will assist as requested by these Stations.

SURVEY OF MARKETING OF FRUITS, FRUIT PRODUCTS, AND TREE NUTS
(BAE-PMA - RM:c-389 - Federal-RMA Funds)

A. Purpose and Nature of Current Work

To (1) discover the factors--such as processing, packaging, pricing, and other merchandising practices--which affect the movement of fruits, fruit products, and tree nuts into domestic distributive channels, as well as into export outlets; (2) discover the factors affecting consumption of fruits, tree nuts, fruit products by industrial users, such as bakers, confectioners, ice cream manufacturers, and others; and (3) assist the fruit and tree-nut industries in obtaining data on consumer purchases and prices of fruits, fruit products, and tree nuts, as well as data on the distribution and stocks of these commodities in distributive channels for their use in developing merchandising programs.

B. Currently Active Line Projects

Consumer purchases of selected fresh fruits, canned and frozen juices, and dried fruits. (Contract) A private market research organization is furnishing the Department of Agriculture with monthly data on volume of purchases, prices paid, average size of purchases, and per capita purchases. The data are then analyzed each quarter by regions, by type of store through which purchases were made, and annually by family characteristics and size of city. The data are obtained from a national sample of about 4,500 families who report their purchases at the end of each week.

Factors affecting distribution and utilization of tree nuts. To (1) determine the factors affecting utilization of edible tree nuts by industrial users--such as bakers, confectioners, ice cream manufacturers, and others-- and (2) determine factors affecting distribution of shelled and in-shell nuts through retail stores.

Collection of data on availability and inventories of fruits and fruit products in retail stores. (Contract) To cooperate with fruit-industry groups in obtaining data on the availability and inventories of certain fresh and processed fruits in retail food stores throughout the United States.

C. History and Evolution of This Work

The Production and Marketing Administration initiated the work under this project in the fiscal year 1949. The Bureau of Agricultural Economics joined in the work during fiscal year 1950.

Confectioners, ice cream manufacturers, bakers, and other industrial users have long formed an important outlet for edible tree nuts. Relatively little has been known concerning the reasons for their selective utilization of these nuts. At the suggestion of the Tree Nut Advisory Committee studies were begun in 1949 to learn the reasons for use or non-use of tree nuts and their products by confectioners, ice cream manufacturers, bakers and other industrial users. An additional study of brokers, wholesalers, jobbers, and retailers is discovering the factors that affect sales of shelled and unshelled tree nuts in retail stores.

The studies of consumer purchasing of fruits, fruit products and dried fruits were started October 1, 1949. The data are obtained under a contract with a private market research organization with one-half of the funds being furnished by participating industry groups and the other one-half supplied by RMA. The contract was made after a study of proposals by several market research organizations. The data have been reported monthly and the contract has been amended to continue for another year ending September 30, 1951.

The Department collected data on retail availability and inventories of selected fruits, juices, and dried fruit at approximately quarterly intervals during 1949 under an experimental contract with a private marketing research organization. After that year of the experimental phase of the contract, which was wholly financed with RMA funds, the industry group believed that these data were of a value that justified a continuation of the contract; the group supplied one-half of the cost of the continued service and RMA the other half.

D. Funds--Annual Expenditures

RMA funds spent on this project by the Bureau of Agricultural Economics amounted to $78,000 during the fiscal year ended June 1950; expenditures by the Production and Marketing Administration in the same year totaled $25,000. Additional expenditure of $51,000 that year was covered by a contribution from the participating fruit-industry group. Expenditures of RMA funds by the Production and Marketing Administration in 1949 were $38,000; but no funds were spent on this project by the Bureau of Agricultural Economics that year. No regular funds have been used in this work.

E. Examples of Outstanding Accomplishments

Distribution of collected information. The Department has published a monthly series, "Consumer Purchases of Selected Fresh Fruits, Canned and Frozen Juices, and Dried Fruits," for each month, January through June 1950. In addition, a quarterly report, "Regional Distribution and Types of Stores Where Consumers Buy Selected Fresh Fruits, Canned and Frozen Juices, and Dried Fruits," was begun in June 1950, and a yearly report, "Consumer Buying Practices for Selected Fresh Fruits, Canned and Frozen Juices, and Dried Fruits, Related to Family Characteristics, Region, and City Size," was also published that month. The data contained in these reports are being used by the industry in making shipment and other marketing decisions. The participating fruit-industry groups have decided to support this work with matching funds for another year beginning October 1, 1950.

This project has, for the first time, (1) made available to all elements in the fruit industry, large and small, authentic and unbiased current information on the purchases of certain fresh and processed fruits by consumers; (2) provided a comprehensive picture of the degree to which these products are available in retail stores in all parts of the country (3) provided similar information on retail inventories, these data being available to the entire fruit industry, as well as to distributors and retailers, and (4) made possible much sounder merchandising programs thar could ever have been developed in the absence of these data.

Benefited the new frozen concentrates especially. This information has been particularly valuable in connection with the marketing of frozen concentrated juices. This new group of products has developed very rapidly over the last few years and production is still expanding at an astounding rate. The movement of these frozen concentrated juices in consumers hands in comparison with the rate at which they are being processed and in relation to competitive products, both processed and fresh, and the information on the extent to which they are becoming available in retail stores throughout the country has proved to be extremely valuable marketing information.

F. Some Additional Work Needed

Analyses as the data accumulated. The data obtained from the panel of families can be useful in analyzing the factors affecting demand for the particular fruits included in the consumer purchase studies. As the length of the time series increases, the value of the data increases and further analysis becomes possible. Analysis of data on the effect of purchases of frozen concentrated orange juice on purchases of canned single-strength juice and fresh oranges is under way on a small scale and should be expanded. Its purpose is to forecast the pattern of consumption in the future by specific areas and to measure the effect of the introduction of frozen concentrated juices. The sample on which these data are based should be converted to a random sample by using the random sampling method. Steps in this direction are going forward under the 1951 appropriation but completion will be considerably later.

Extension of coverage. In spite of the value of this work, it has had its limitations. During last year, when the work was financed jointly by industry and the Department, the project was limited to obtaining information on fresh citrus fruits, canned and frozen juices of all kinds, and dried fruits, because funds were available only from the citrus and dried-fruit groups. Additional groups have indicated a wish to participate during the current year, but the work should be extended still farther to include the whole range of fresh, canned, and frozen deciduous fruits.

Collection of data regarding purchases by institutional users. As it is estimated that institutional use accounts for 15 to 25 percent, or more, of various fruits and fruit products, it is essential that information on the movement into this outlet be obtained if a complete picture of the marketing of these commodities is to be had.

Collection of data on tree nuts. The same kinds of information with regard to movement and distribution should be collected and distributed on tree nuts. Because of the importance of the utilization of tree nuts by industrial users, such as bakers, confectioners, and ice cream manufacturers, any data on movement at retail should be supplemented by information on movement to these industrial users in order to provide a comprehensive picture of tree-nut marketings.

METHODS OF HANDLING, TRANSPORTATION AND STORAGE OF DECIDUOUS FRUITS
(BPISAE - b-8-1 Federal - State - Regular Funds)

A. Purpose and Nature of Current Work

To (1) develop means of evaluating maturity, to investigate methods of harvesting, handling, packing, precooling, storing and transporting deciduous fruit and (2) develop the most efficient and economical practices that can be used commercially to deliver to the ultimate consumer fruit of the best quality in prime condition. The current work is particularly concerned with investigations of protective services in rail and truck transportation, methods of transporting frozen foods, determination of maturity of fruits, methods of ripening pears, studies on air purification in storages, and prevention of grape shattering in transit.

B. Currently Active Line Projects

b-8-1-1 - Maturity of apples; developing means of evaluating maturity and determining the optimum maturity for various purposes. The optimum degree of maturity for storage, shipping, and processing differs and it is desirable to develop practical and accurate methods of measuring and evaluating the different degrees of maturity.

b-8-1-2 - Maturity of pears, developing means of evaluating maturity and determining the optimum maturity for various purposes. Same as under b-8-1-1.

b-8-1-3 - Maturity of plums, peaches and other stone fruits; developing means of evaluating maturity and determining the optimum maturity for various purposes. Same as under b-8-1-1.

b-8-1-4 - Maturity of grapes, berries and other small fruits; developing means of evaluating maturity and determining the optimum maturity for various purposes. Same as under b-8-1-1.

b-8-1-5 - Packing and storing deciduous fruit. To determine the effect of various types of packing materials on the fruit in transit and storage; the effect of gaseous respiration products on ripening, taste, and development of disease; the effectiveness of air purification methods in removing undesirable gases from storage rooms; and to determine the optimum storage temperatures for maintaining fruit in prime marketing condition.

b-8-1-6 - Precooling and transportation of deciduous fruits with particular reference to refrigeration in transit during warm weather and protection against freezing in cold weather. To determine the effective, practical, and economical methods of precooling, and the most desirable refrigeration, ventilation, or heating service to insure delivery of high quality fruits to the market.

b-8-1-7 - Ripening fruits to secure maximum quality; changes in composition during ripening and storage. To determine the best temperatures to ripen fruits to obtain the best dessert quality for market or processing and to determine the effect of new insecticidal sprays on ripening, storage life, and quality of fruit.

b-8-1-8 - Investigations on the most efficient utilization and operation of cold storage facilities for apples and pears in the Pacific Northwest. To study different types of cold storage plants, methods of stacking to provide air circulation, and the use of pallets.

b-8-1-9 - Testing different kinds of refrigerator cars for effectiveness in protecting heavy loads of fruits moving under ventilation, refrigeration and heater service. To determine the effectiveness of improved draft gears and underframes in protecting the load from breakage and bruising caused by heavy impacts; the effect of heavy loads on the packages in the bottom layer; and the effect of the tightness of the load.

b-8-1-10 - Storage quality of new bud sport varieties of apples. Storage tests of bud sport varieties are conducted to compare their keeping quality and susceptibility to storage diseases with that of parent varieties.

b-8-1-11 - The effect of hormones applied either before or after harvest on eating quality and keeping quality of apples, pears, grapes and other fruits. The effect of growth substances such as naphthalenacetic acid and amyl ester of 2,4-D on development of scald on apples, and of these and other substances on growth and coloring of figs is being studied.

b-8-1-13 - Prevention of shriveling of apples in storage; waxing apples and its effect on keeping quality. To test the effectiveness of different kinds of wax and methods of application in preventing shriveling, and to determine the effect on the physiology and keeping quality of the fruit.

b-8-1-14 - Storage of dried fruit. To study the influence of storage temperature and length of storage on color, flavor, and "sugaring" of dried fruit.

b-8-1-15 - Spray residue removal from fruit. To develop methods of removing excess spray residue efficiently and without injury to the fruit.

C. History and Evolution of This Work

Research on the handling, transportation and storage of deciduous fruits became one of the major activities of the Bureau of Plant Industry when it was organized in 1901 and has continued so to date. The early investigations demonstrated that by means of refrigeration it was economically practical to prolong the marketing period and to transport fresh fruits to distant points in this country and overseas. Further studies have resulted in improved design of refrigerator cars and their more efficient use during summer and winter months. These studies have been extended to truck and air transport. The cold storage requirements for fruits and vegetables have been determined and good commercial storage practice established. Studies have been made on maturity of apples, pears, and other fruits in relation to storage life, quality, and ripening; and maturity standards have been developed and put in use by the apple and pear industry. Investigations have been made on the effect of various methods of harvesting, handling, and packing on bruising and on the importance of bruises in relation to keeping and market quality.

D. Funds - Annual Expenditures

Allotments from 1901 to 1920 ranged from about $5,000 to $25,000, increased to $40,000 by 1929 and to $104,520 in 1949. The 1950 allotment was $92,350.

E. Examples of Outstanding Accomplishments

Refrigeration in storage and transit increased useful life of fruit. Early investigations demonstrated that by means of refrigeration it was possible to store fresh fruits for long periods and to ship them to all parts of the country and overseas. Most of the practices now in use for the storage and shipping of fruits and vegetables have been developed by this Bureau working with the storage and transportation agencies. A storage manual, Circular 278, was issued in 1933 and has gone through several revisions. This Circular gives recommended storage practices and is used as a manual by the cold storage industry. A similar publication is being prepared for refrigeration in transit.

Studies on the carbon dioxide gas treatment of sweet cherries in transit have shown that the treatment retards coloring and ripening and reduces decay enroute to market. Value of gas treated consignments often amount to 25 cents per lug, or about $300 a car more than similar lots shipped without gas.

Studies on shattering of grapes in transit showed that the most important factor was the amount of slack in the load and that damage was greatly reduced if the load was tightly squeezed and well braced. The results are applicable to some 30,000 carloads that are shipped annually.

Studies on heater protective service for winter shipments demonstrated the undesirable effects of excessively high temperatures in the upper part of the load and the importance of the use of thermostatically controlled heaters to avoid such conditions. Evidence from these studies was partly instrumental in obtaining an Interstate Commerce Commission order for the railroads to provide thermostatically controlled heater service.

Studies on air purification in apple and pear storages at Wenatchee have shown that activated-carbon air filters do not remove ethylene, the principal cause of accelerated ripening, from the air nor prolong the storage life of the fruit. Since the cost of installation and operation of activated-carbon filters is high these findings are important to storage operators.

Studies on air transport of fruits, vegetables and flowers have shown that pressurized cargo compartments are not needed since these commodities were tolerant of elevations of 50,000 feet and rapid changes in elevation. Protection from dry, warm air in flight was the most important consideration in preventing deterioration.

F. Some Additional Work Needed

Development of new refrigeration, storage and transportation facilities. New equipment and facilities are continually being developed and research is necessary to determine their advantages and disadvantages and their best utilization and operation for different kinds of deciduous fruits.

Truck transportation. The tremendous growth of the trucking industry in recent years has resulted in a demand for special research on that method of transportation. There is need for studies on design, insulation, refrigeration, and methods of loading as a basis for improvements in equipment and efficient operation. Work on this problem has already been started.

Air purification. Research is needed on the removal of undesirable gasses from storages. Studies now being conducted indicate that absorbent filters now in commercial use for air purification are not as effective as desired. Further studies are needed to develop improved filters and methods of purifying the air by controlled ventilation and other means.

MARKET DISEASES OF FRUITS AND VEGETABLES
(BPISAE - b-8-4 Federal-State - Regular Funds)

A. Progress and Nature of Current Work

To investigate the occurrence and causes of market diseases of fruits and vegetables, to study the factors that contribute thereto, and to develop methods of prevention and control.

Fruit and vegetable diseases that develop in transit, storage, and at the market are responsible for serious losses. A survey at New York City showed that, for the period 1935 to 1942, the spoilage on arrival amounted to nearly 3,000 carlots annually. The economic importance of spoilage during marketing is even greater than damage to the growing crop because of the additional cost of time, labor, packing materials, and transportation concentrated in the harvested product en route to market. The market disease studies are conducted by the market disease laboratories at New York and Chicago, at field stations and other points in the growing areas, and during shipment in trains, ships, planes, and trucks. The organisms causing diseases are identified, their importance and conditions causing losses are determined, and methods for reducing the losses are developed. Instruction classes are conducted for inspectors and market disease manuals for the important fruits and vegetables are prepared and revised periodically.

B. Currently Active Line Projects

b-8-4-1 - Bacterial soft rot of new potatoes and other vegetables. To study the organisms that cause bacterial soft rot, to determine the relation of temperature and handling practices to infection and growth, and to develop methods of control.

b-8-4-3 - Rhizopus, black rot, and other diseases of sweet potatoes, particularly as affected by washing, waxing, packing, and storage practices. To determine the effect of grading, cleaning, and packaging processes and storage practices on the development of market and storage diseases and to develop methods of reducing the losses.

b-8-4-5 - Sulfur dioxide fumigation of California grapes to control Botrytis rot and other types of decay. To determine the relation of time of infection to effectiveness of sulfur dioxide in controlling decay and to determine the optimum dosage and number of applications of the gas to obtain good control without damaging the grapes. Work to be expanded under RMA 413.

b-8-4-7 - Core browning of Rhode Island Greening and McIntosh apples in New York and New England States. To study factors involved in core browning and develop control measures.

b-8-4-8 - Stylar end breakdown of Persian limes from Florida. To study the nature, cause, and methods of preventing stylar end breakdown of Persian limes.

13-130 b-8-4-11 - Apple scald; physiology; rechecking effectiveness of control by oiled wraps with different kinds of oil and degrees of saturation. To obtain further information on the physiology of apple scald and to develop more effective methods of control.

b-8-4-14 - Soft scald of apples. To investigate the nature of soft scald and methods for its prevention. No work has been done in recent years, but there is need for further studies.

b-8-4-15 - Antiseptic treatments for fruits and vegetables; tests with different materials and methods of application. To test antiseptic materials for effectiveness against various vegetable and fruit-rotting organisms, to determine the tolerance of vegetables and fruits to these materials, and to develop practical methods of using antiseptics for the control of spoilage in storage and in transit.

b-8-4-16 - Disinfection of storage houses, field boxes and baskets; tests with different materials and methods of application. To determine the need for disinfection, to test the effectiveness of disinfectants, and to determine the possibility of the treatments causing injury to the contents of the treated packages.

b-8-4-17 - Rots of stone fruits in the Pacific Northwest. To develop methods of controlling brown rot, rhizopus rot, and other decays of stone fruits.

b-8-4-18 - Storage diseases of peanuts. To identify and determine the relative importance of the different fungi and bacteria associated with damaged peanuts on the market, to determine their virulence and to catalog and describe the characteristic symptoms caused by each.

b-8-4-19 - Control of watery soft rot of beans, celery, and other vegetables in transit and on the market. To determine practical methods to control this disease in storage and in transit.

b-8-4-20 - Miscellaneous market and storage diseases of fruits and vegetables. To isolate and identify the causal organisms, to determine the time and method of infection and the temperature relations, and to develop practical control methods of diseases that may appear from time to time in market or storage.

b-8-4-21 - Effect of decay organisms on the tissues of fruits and vegetables in storage. To determine the histological and physiological effect of various decay organisms on the fruit and vegetable tissues.

C. History and Evolution of This Work

Investigation of market diseases was formally provided for by the establishment of market disease laboratories in New York City and Chicago in 1917. Prior to that time work on diseases causing market losses had been conducted as a part of various production research projects. The early work was concerned largely with determination of the important diseases that are encountered on the market, and the nature and amount of the losses caused by them. Later the studies were extended to determine the factors at the producing and shipping point and in transit that contribute to the development of market diseases and to study diseases in storage. The control of diseases that may spoil the crop after it is shipped is even more important than protection during the growing period, because the fruits and vegetables then represent an investment not only for growing but for harvesting, packaging, storage, and transportation.

D. Funds--Annual Expenditures

Allotments from 1901 to 1920 ranged from about $5,000 to $20,000, increased to $30,000 in 1930, and from $33,000 to $48,000 during the past 16 years. The 1950 allotment was $50,780.

E. Examples of Outstanding Accomplishments

Market disease manuals. A series of 8 market disease manuals illustrated with color plates and covering the market diseases that affect over 20 of the important vegetable and fruit crops were issued from 1932 to 1944. These publications gave a comprehensive coverage of the knowledge of market diseases, much of which was based on investigations conducted under this project. These manuals have become recognized as standard guides to market diseases and are constantly used by research workers, the fruit and vegetable industry, the government and private inspection agencies, and transportation and storage organizations.

Chemical control of citrus decay. The commercially used borax treatment for control of citrus decay is based on findings under this project. More recent studies have resulted in the development of a sodium ortho-phenylphenate treatment which is more effective than the borax treatment. It has been substituted for the borax treatment by some packing houses.

Potato spoilage caused by heat injury. Studies on potato spoilage have shown that much decay is caused by injury from exposure to heat rays from the sun. The temperatures and length of exposure that cause heat damage have been determined.

Cause of potato lenticel infection determined and corrected. Studies in California and Chicago demonstrated that a certain type of bacterial soft rot was caused by bacteria being forced into the lenticels of the tuber by hydrostatic pressure in deep washing tanks. This type of decay was controlled by reducing the time the potatoes were in the tank and chlorinating the water.

Studies on ultraviolet light for disinfecting fruits. Investigations in Florida, California, and Washington showed that ultraviolet light was not effective in preventing fruit decay. As a result of these findings large expenditures for ultraviolet treatment in commercial packing sheds were avoided.

13-132 Control of apple scald by oiled fruit wrappers. Research in the Northwest lead to the development of oil impregnated wraps which are now in general commercial use for control of apple scald. The use of these wraps has been estimated to have increased the sales price 25 cents a bushel and conservative estimates place the value to the American apple industry at over $1,000,000 annually.

Control of botrytis rot of pears by copper impregnated fruit wrappers. Experiments in the Northwest led to the development of copper-impregnated wrappers to control gray mold or nest rot of pears. These wrappers are in general commercial use and have resulted in important monetary savings.

Control of citrus fruit decays with diphenyl. Recently experiments have determined the effectiveness of diphenyl vapors against various rot fungi and demonstrated the value of diphenyl-impregnated wrappers, box liners, and cardboard cartons for controlling citrus decay. These are being used extensively in the marketing of citrus shipped from the southeastern states.

Control of pineapple decay. A practical control for black rot of Puerto Rican Pineapples which was causing up to 25 percent decay in transit was developed. The treatment consisted of painting the freshly cut butts of the fruit with a disinfectant before they were packed.

Control of banana diseases. The treatment cost only about 1/2 cent a box for labor and material and practically eliminated the losses. Recent investigations in Chicago and in producing areas in Central America have determined the cause of an important market disease of bananas and promising results are being obtained in control experiments.

Studies on ozone for prevention of apple decay in storage. Studies at Beltsville demonstrated that ozone did not prevent decay or reduce infection of wounds and that there was danger of injuring the fruit and impairing the flavor. These findings have forestalled the installation of expensive ozone generators in many commercial fruit storages.

Effect of Carbon dioxide on decay of fruits and vegetables. Investigations with 40 different kinds of fruits and vegetables in the Northwest, California, Texas, and other areas showed that carbon dioxide was effective in controlling decay in plums, peaches, Bartlett pears, raspberries, figs, grapefruit, oranges and sweet cherries. It was found that, in general, a short period gas treatment was as effective in retarding decay and maintaining firmness as immediate storage at 32°F. and did not impair the flavor. As a result of actual transportation tests the use of carbon dioxide as a supplement to ordinary refrigeration has come into general use by Pacific Coast cherry shippers and approximately 375,000 pounds of dry ice are used annually for this purpose. The better quality fruit resulting from the treatment in some cases commands as much as $300 more per car.

F. Some Additional Work Needed

In spite of the extensive studies on market diseases during the past 30 years much remains to be learned.

Identification of new diseases. The identification of new diseases and determination of the factors favoring them is continuous because new diseases are constantly being encountered in transit, storages, and the markets as new producing areas are developed and as the market season is extended for an increasing variety of fruits and vegetables.

Development of control measures. Further work is needed to develop effective and economical controls for many important diseases for which satisfactory treatments have not been developed yet and to test new antiseptic chemicals as they become available.

Revision of market disease manuals. These manuals need to be revised periodically to keep them up to date. Three have already been revised and revisions of others have been started.

INVESTIGATIONS OF METHODS OF RIPENING WINTER PEARS AFTER SHIPPING AND STORING BEFORE OFFERING FOR RETAIL SALE IN EASTERN MARKETS AND DEVELOP TESTS TO FORECAST THE PROGRESS AND RATE OF RIPENING.

(BPISAE-RM: c-552 - Federal-- RMA Funds)

A. Purpose and Nature of Current Work.

To develop practical commercial methods for ripening winter pears in transit and at the markets and to develop tests by which the progress and rate of ripening can be followed and the date the fruit will be suitable for retail marketing can be forecast.

Winter pears must be ripened at a moderate temperature before they are edible. Many pears on the retail market have not been ripened and consumers who buy them for immediate use are disappointed and unlikely to make a repeat purchase. Investigations under this project are concerned with developing methods by which high-quality ripe pears can be marketed with a minimum of delay and expense at the terminal markets, and with developing measures of rate of ripening by which the time fruit will reach optimum marketing condition can be forecast.

B. Current Active Line Projects.

c-552-1 - Develop method of ripening winter pears in transit and at the market terminals. To develop methods of ripening the fruit while in transit and in cars or special ripening rooms at the terminal market and to correlate time, temperatures, and firmness with progress in ripening so as to develop methods of forecasting the rate of ripening.

C. History and Evolution of This Work.

The investigations on the handling of pears, their ripening and storage were begun in 1901 in this Bureau and the results of these early tests were published in 1903 in BPI Bul. 40. Since then a large amount of work has been done in this field covering all of the important commercial varieties. Much is now known of the processes that go on in pears as they are stored and ripened. Recent work was published in 1941 in Tech. Bul. 759. This specific project, dealing with the ripening of pears was started in the fall of 1949.

D. Funds - Annual Expenditures

Funds provided in the 1950 fiscal year, when the work started, totaled $11,500.

E. Examples of Outstanding Accomplishments.

Ripening in transit. Transportation tests have shown that by installing bunker heaters in the cars at Chicago it is possible to raise the temperature of the fruit to 60°F. from an initial temperature of about 40°, during the 2 days enroute from Chicago to New York and thus shorten the ripening period at the market by about 1 1/2 days.

Ripening in refrigerator car at the market. Tests with Oregon pears at the New York terminal showed that it was possible to raise the fruit temperature from about 41°F. to 65° or higher in about 48 hours by means of bunker heaters and the car fans operated by auxiliary motors. This demonstrated that ripening temperatures could be obtained in the cars and the expense of transferring the fruit to special ripening rooms avoided.

Ripening test. Ripening tests with Oregon pears in New York and at Beltsville showed that firmness as determined by pressure test was a good measure of ripeness. It was found that fruit with a pressure test of about 6 to 7 pounds was firm enough to handle without bruising, but far enough advanced to ripen to good quality in the retail store. This information is now in general use by chain stores and other agencies that ripen pears for consumers and the pressure tester has been of great help in taking the guesswork out of ripening.

F. Some Additional Work Needed.

More varieties need to be studied. Most of the work to date has been with Bosc and Anjou pears. The same type of studies should be made with Bartlett, Comice, and Winter Nelis.

The relation of ripeness to bruising needs further study. Such investigations should include all the important winter pear shipping varieties.

The method of ripening pears in transit and in the cars at market needs to be perfected.

DEVELOPMENT OF METHODS OF HANDLING AND SHIPPING PEACHES TO WIDEN DISTRIBUTION OF FRUIT RIPENED TO HIGHER QUALITY

(BPISAE-RM:c-553 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

To (1) develop methods of handling and shipping by which it will be possible to deliver riper and better quality peaches to the consumers (2) develop a commercially practical index of maturity (3) determine the effect of orchard spraying and post-harvest fungicidal treatments on control of decay, and (4) to test new types of packages.

Peaches shipped to distant markets are generally inferior in quality because they are picked too green and because of decay and bruising in transit. In order to increase consumer demand and improve the market it is essential that practical means be developed of furnishing the consumers with a better quality product. To accomplish this studies are being made of possible indexes of maturity, new types of packages to reduce bruising damage even when riper peaches are shipped, and methods of reducing decay by use of chemicals and refrigeration.

B. Currently Active Line Projects

c-553-1 - Develop improved methods for packing, handling, and shipping peaches ripened to higher quality. To develop methods of marketing riper and higher quality peaches without excessive losses from spoilage and decay.

C. History and Evolution of this Work

One of the earliest publications of the Bureau of Plant Industry dealt with the cold storage of peaches and pears - B.P.I. Bul. 40, 1903. Various problems relating to the shipping and handling of peaches have been attacked since then and the results published. The findings in respect to storage were published in 1939 in Technical Bul. 680. The present project was initiated in the summer of 1949.

D. Funds - Annual Expenditures

Funds alloted to this project in its first year, 1950, amounted to $11,500.

E. Examples of Outstanding Accomplishments

Test for maturity. Investigations to date indicate that a practical measure for maturity may be developed using combination of color and pressure factors.

Shipping riper peaches. Results of shipping tests show that peaches in the firm mature stage can be shipped successfully and then ripened after they reach the market.

F. Some Additional Work Needed. 13-137

A test for maturity should be perfected that is suitable for commercial use.

Development of fungicidal treatments that will control decay in transit.

Development of suitable packages for use in shipping ripe peaches.

REGIONAL RESEARCH IN MARKETING AND DISTRIBUTION FROM HARVESTING TO CONSUMERS, INCLUDING PROCESSING, OF FRUITS AND THEIR PRODUCTS

(BPISAE-PMA - RM:c-275 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

To (1) assist fruit growers in increasing their returns through better grading and handling practices, (2) assist shippers and packers in finding more efficient means of storing, packing, and handling fruits, to reduce costs, and (3) benefit consumers through making available fruits of better quality in retail markets. This cooperative work with the experiment stations in the Northeastern States in the regional research project on marketing fruits is directed toward (a) the determination, measurement, and maintenance of desirable qualities in fruits and their products, (b) adapting the measurements of quality for possible use in the United States standards and grades, (c) determining the grade of various lots of fruits used in connection with the work of experiment stations, and (d) determining the amount of deterioration and the effect of such deterioration in quality of fruits, particularly apples and peaches, upon market acceptance.

B. Currently Active Line Projects

RM:c-275-1 - To study internal defects, wastage due to bruising and other injuries and effect of methods of packaging on Northeastern fruit marketed in New York, Baltimore, and Washington areas. To analyze samples of Northeastern fruits collected in the markets for defects and causes of the defects.

C. History and Evolution of This Work

The introduction of new varieties of fruits, expanded use of motor trucks, development of consumer packages, and other new developments have affected cost, deterioration, quality, and consumer acceptance. BPISAE and PMA have cooperated with the States in analysis of samples of Northeastern fruits on the markets in New York City, Baltimore, and Washington in regard to grade, causes of deterioration, cost, and consumer acceptance. Such information obtained in the market channels will assist the States in instituting corrective measures in the producing areas.

D. Funds - Annual Expenditures

	PMA	BPISAE	TOTAL
1949	$ 100	$ 950	$1,050
1950	$3,000	$2,000	$5,000

E. Examples of Outstanding Accomplishments

Storage and packaging tests with cranberries have shown the best storage temperatures, how long this fruit will keep under ideal conditions and the disorders that may be encountered due to storage temperature, time stored, or smothering. This has enabled cranberry producers and marketing agencies to improve storage practices, reduce spoilage losses, and thus reduce their costs.

Storage tests with Maine-grown McIntosh apples in New York failed to show any benefits from air purification by means of activated charcoal filters. These results were in line with those obtained in more extensive studies at Wenatchee, Wash.

Lots of peaches followed from shipping points in New Jersey and Maryland through the marketing channel to the New York City wholesale market indicated that, on the average, growers and shippers were removing during the packing process only a small percentage of grade defects found in peaches at the orchard. This was found to be one of the principal reasons for the poor condition of New Jersey and Maryland peaches upon arrival in New York.

F. Some Additional Work Needed

Further work should be done on the effect of air purification on storage of various kinds of Northeastern fruits.

Tests should be continued on cranberries and investigations should be initiated on other Northeastern fruits such as blueberries, currants, etc.

Preliminary work relating to the bruising of apples offered for sale in retail stores in Portland, Maine, indicates the desirability of additional work to associate such bruising and deterioration with methods of handling and determining effects of such bruising upon market acceptance.

In connection with the work on peaches conducted in New Jersey and Maryland, additional research is needed to determine the extent to which defective peaches may be removed before shipment from producing area without incurring prohibitive costs.

IMPROVING THE MARKETING METHODS AND DISTRIBUTION OF FRUITS AND VEGETABLES
(PMA - Federal - Marketing Farm Products Funds)

A. Purpose and Nature of Current Work

To make available to growers, shippers, handlers, and others data and material upon the preparation of fresh fruits and vegetables for market and material describing those characteristics responsible for desirable qualities in fresh produce, particularly as such information relates to grading and standardization. In making such information available generally to the public, bulletins have been prepared describing the preparation of produce for market, latest recommended practices used in the harvesting, grading, packing, loading, and distributing. These bulletins are particularly valuable and save time in answering specific inquiries and correspondence relative to market preparation, grading, handling, and standardization.

B. Currently Active Phases of This Work

In order to bring the current bulletins on strawberries and peaches up to date and incorporate descriptions of new practices, work is proceeding on the revision of Farmers' Bulletin 1560, "Preparing Strawberries for Market," and Farmers' Bulletin 1702, "Preparation of Peaches for Market." The former was completely rewritten and has been submitted for publication. Field study is being conducted on the latter for the purpose of gathering new material and new photographs.

C. History and Evolution of This Work

Shortly after the inauguration of the standardization and inspection program of the Department it was realized that methods would have to be developed for acquainting industry representatives, inspectors, State marketing officials and other interested parties with the purposes of the program and the best methods for achieving them. Various staff members, therefore, were assigned to write publications dealing with marketing and preparation of products for market. Specialists who had worked on the development of standards for certain products were especially qualified to prepare publications dealing with marketing and the preparation of the products for market. Such material was often prepared during the winter months, when field work pertaining to the development of standards could not be conducted.

D. Funds--Annual Expenditures

Funds for this work over the years have averaged around $15,000 to $20,000 annually. However, in the past 2 years the need for fruit and vegetable standardization work has resulted in some reduction in this activity. In 1950 about $10,000 was used for this work.

E. Examples of Outstanding Accomplishments

The data and information on preparation of fruits and vegetables for market and the description of harvesting, grading, packing, loading, and distributing practices have been instrumental in bringing about improvements in the handling of fruits and vegetables. The bulletins have been useful in providing producers, packers, handlers, consumers, teachers, and others with information on the accepted and best practices in the handling of these commodities.

The Department has always had a great demand for bulletins or leaflets which show and describe diagrams of the packs of fruits and vegetables where certain arrangements are necessary in order to obtain the desired sizes and counts. Farmers' Bulletin 1457, "Packing Apples in Boxes," and Farmers' Bulletin 1291, "Preparation of Fresh Tomatoes for Market," are examples of publications of this type. Packing house foremen in shipping areas often use the diagrams of the various packs to show their workers the proper methods of packing commodities in standard containers.

Perhaps the bulletin which has had the widest distribution is Miscellaneous Publication 167, "A Fruit and Vegetable Buying Guide for Consumers." This bulletin was first issued in 1933 and has been revised in 1941 and again in 1948. It is very much in demand. It describes those qualities consumers and other buyers should look for in selecting fruits and vegetables.

Another popular bulletin is Miscellaneous Publication 604, "Standardization and Inspection of Fresh Fruits and Vegetables," which was released in 1946. It has been of particular interest to those desiring to learn the history of the development of standardization and inspection for fresh fruits and vegetables and has been useful in disseminating knowledge as to how standards are developed and applied.

F. Some Additional Work Needed

The bulletins entitled "Packing Apples in Boxes" and "Preparing Apples for Market in Barrels and Baskets" need revision and bringing up to date. They should be consolidated. This work needs to be done in order to bring together information and data relative to new developments and practices in apple marketing.

Study is needed also preparatory to the writing of bulletins on a number of products not now covered by departmental bulletins such as peas, broccoli, plums and prunes, and pears.

CROSS REFERENCES - MARKETING

For additional information especially pertinent to the subjects reported on in this chapter see also:

BAE - A-2-5 and RM:c-32 - Chapter 27, consumption of canned fruits and vegetables.
BAE - A-2-16.1 to 24.1 - Chapter 26, research and analysis for serving current requests on fruit marketing.
BAE - RM:c-205 and a-2-16 - Chapter 26, marketing practices.
BAE - RM:a-417 - Chapter 26, market outlets for apples, peaches, and apricots used in pies.
BAE - PMA, OES, BHNHE, BAIC, BDI, BPISAE, BEPQ - RM:a-c-518 - Chapter 26, technological changes affecting marketing and utilization.
BAE - Chapter 32 - reports on crop and livestock estimates.
BAE - Chapter 33 - commodity market news service.
BAIC - RM:a-421 - Chapter 19, temperature requirements of frozen furits in warehouses and in transit.
BEPQ - RM:c-304 - Chapter 14, insect debris in processed fruits and vegetables.
EXT - RM:c-95 - Chapter 37, fruit marketing.
EXT - RM:c-96 - Chapter 37, consumer education on apples, cherries, apricots, etc.
EXT - Chapter 37, educational work in marketing fresh fruits.
FCA - a-1-4 - Chapter 14, assistance for fruit and vegetable cooperatives.
FCA - RM:c-84 - Chapter 14, merchandising products processed by horticultural cooperatives.
BPISAE - e-2-3 - Chapter 30, storage structures and equipment.
BPISAE - e-3-4 - Chapter 30, farmers cooperative fruit and vegetable freezing plants.
BPISAE - RM:a-45 - Chapter 14, decay in transported fruits and vegetables.
BPISAE - RM:c-52 - Chapter 20, refrigeration at source and market.
BPISAE - RM:c-217 - Chapter 36, improved processing facilities for rural plants.
BPISAE - RM:c-294 - Chapter 37, bibliography on biology and handlinh.
BPISAE - RM:c-413 - Chapter 20, cold storage of apples, grapes, etc.
OFAR - Chapter 23 (especially RM:c-2 and RM:c-544) foreign competition and markets.
PMA - Chapter 35, Administration of U. S. Warehouse Act.
PMA - Chapter 34, Development of Grades and Standards for fresh fruits, fresh vegetables, nuts and miscellaneous products.
PMA - Chapter 19, freight rates for farm products.
PMA - Chapter 34, inspection of fresh fruits and vegetables.
PMA - Chapter 13, improving marketing methods and distribution of fruits and vegetables.
PMA - Chapter 35 - marketing regulatory acts applicable to fruits and vegetables.
PMA - Chapter 36 - obtaining adequate marketing, storage and transportation facilities.
PMA - Chapter 34, processed fruit and vegetable inspection.

CROSS REFERENCES - MARKETING (contd.)

PMA - FCA,OES,BPISAE - RM:a-c-44 - Chapter 36, prepackaging of horticultural products.
PMA - FCA-RM:c-75 - Chapter 36, market facilities, organization and equipment.
PMA - RM:c-85 - Chapter 34, grades and standards.
PMA - RM:c-86 - Chapter 36, expanding market outlets, etc.
PMA - RM:c-106 - Chapter 36, improving distribution methods and practices.
PMA - BAE - RM:c-133 - Chapter 34, adequacy of grades and standards.
PMA - RM:c-167 - Chapter 19, peach transportation.
PMA - RM:c-286 - Chapter 19, standards for containers.
PMA - RM:-c-387 - Chapter 34, consumer grades.
PMA - RM:c-430, 431, 432 - Chapter 36, marketing service programs.

630.7
Un37re
v.2^12
cop.2

RESTRICTED
For administrative use only

REPORT ON RESEARCH, SERVICE, AND MARKETING EDUCATIONAL WORK IN THE UNITED STATES DEPARTMENT OF AGRICULTURE

Part II - Chapter 12

Citrus and Subtropical Fruits

Prepared at the request of the
House Committee on Agriculture
Special Subcommittee
Honorable Stephen Pace, Chairman

United States Department of Agriculture
Washington, D.C.--November 1950

General Comment

The research, service, and marketing educational activities covered herein are reported for the most part on the basis of "work projects," the level at which various U. S. Department of Agriculture agencies keep separate financial records and prepare separate annual progress reports. The statements for these work projects give pertinent information on the nature and purpose of the work being carried on, and on the currently active "line projects," which are subdivisions of activity under the broader work projects. They also cover the history and development of the work, the Federal funds (and in a few instances the State funds) expended, some of the accomplishments, and some of the additional work needed in the areas covered by the work project.

Much of the work reported in this and other chapters of the over-all report is conducted in close cooperation with State agencies. While Federal-State cooperation is indicated for all such projects, it has not been feasible to report in detail the extent and nature of such cooperation. Also, except in specific types of work, no effort has been made to indicate the contributions of cooperating State agencies from the standpoint of accomplishments even though in many instances such contributions have been very important.

It should also be pointed out that the material in the over-all report has been organized, as far as possible, for the convenience of members of the Congress, members of commodity and functional advisory committees under the Research and Marketing Act, and others who are especially interested in specific segments of research, service, or marketing educational work.

- - - - - - - -

Abbreviations of Agency Names

The numbering system used throughout this report includes the initials of the operating agency of the Department conducting or supervising the work.

ARA	Agricultural Research Administration
BAI	Bureau of Animal Industry
BAIC	Bureau of Agricultural and Industrial Chemistry
BDI	Bureau of Dairy Industry
BEPQ	Bureau of Entomology and Plant Quarantine
BHNHE	Bureau of Human Nutrition and Home Economics
BPISAE	Bureau of Plant Industry, Soils, and Agricultural Engineering
OES	Office of Experiment Stations
BAE	Bureau of Agricultural Economics
CEA	Commodity Exchange Authority
EXT	Extension Service
FCA	Farm Credit Administration
FS	Forest Service
OFAR	Office of Foreign Agricultural Relations
OI	Office of Information
PMA	Production and Marketing Administration
SCS	Soil Conservation Service

Table of Contents

Page

FOREWORD
CITRUS AND SUBTROPICAL FRUITS

A - Production

Citrus fruits

BPISAE-b-2-1-Citrus production, diseases and improvement . . 12-1
BPISAE-RM:b-531-Citrus rootstocks resistant to diseases, nematodes, etc. 12-5
BEPQ-I-a-2-Fruit fly investigations in Mexico. 12-7
BEPQ-I-a-3-Fruit fly investigations in the Canal Zone. . . . 12-10
BEPQ-I-a-4-Citrus blackfly investigations. 12-12
BEPQ-I-b-9-Citrus and other subtropical fruit insects. . . . 12-16
BEPQ-I-o-1-Biology and ecology of the Oriental fruit fly . . 12-23
BEPQ-I-o-2-Biological control of the Oriental fruit fly. . . 12-26
BEPQ-I-o-3-Chemical control of the Oriental fruit fly. . . . 12-28
BEPQ-I-o-4-Area control of the Oriental fruit fly. 12-32
BEPQ-I-o-5-Destruction of the Oriental fruit fly by commodity treatment. 12-35
BEPQ-I-o-6-Physiology of the Oriental fruit fly 12-38
BEPQ-RM:b-264-Fruit flies, natural enemies. 12-39
BEPQ-I.E.O.F.-Citrus canker survey. 12-41

Sub-Tropical fruits

BPISAE-b-2-2-Avocado, fig, mango, and miscellaneous sub-tropical fruits, production, diseases, and improvement 12-43
BPISAE-b-2-3-Date production, diseases and improvement. . . 12-45
OES-b-1-9-Food crop investigations-Puerto Rico. 12-48
Cross References 12-52

B - Utilization

BAIC-b-1-Southern fruit and vegetable processing investigations, etc.. 12-53
BAIC-b-8-Utilization investigations on fruits, vegetables, and other agricultural products of the West.. 12-58
BAIC-RM:a-140-New and improved uses of citrus products . . . 12-66
BAIC-RM:a-504-Measure bitter principles in orange juice. . . 12-70
Cross References 12-71

C - Marketing

BAE-RM:c-31-Consumer preferences research on citrus fruits . 12-72
BAE-RM:c-163-Costs and margins 12-74
BAE, PMA, FCA-RM:b-191-Regional marketing research in citrus fruits. 12-76
BEPQ-RM:c-305-Sterilizing citrus fruit against Mexican fruit fly, etc. 12-78
FCA-RM:c-419-Reduce margins and handling costs by testing new equipment and developing improved procedures . . 12-80
FCA-RM:c-554-Coordinated selling of citrus fruits in Florida 12-82
BPISAE-b-8-2-Handling, transportation and storage of citrus and other sub-tropical fruits. 12-84
PMA-RM:c-549-Frozen concentrated citrus juices on price structure and marketing practices of other citrus and products 12-87
Cross References 12-89

FOREWORD

This chapter in the report on USDA research, service and marketing educational work consists principally of reports on the research work with citrus and subtropical fruits classified under the three broad divisions of production, utilization and marketing. Under production are placed the reports dealing with cultural practices, breeding and improvement, and disease and insect control; under utilization those concerned with fundamental studies as well as those designed to develop new and expanded uses as human food, for industrial utilization or for livestock feed; under marketing those concerned with handling, transportation and storage, consumer preferences, commodity and product competition, costs and margins and regional marketing research. Although the over-all report deals chiefly with USDA activities, it does include some of the work on citrus and subtropical fruits by State Agricultural Experiment Stations (Chapter 39), State Extension Services (Chapter 37), and State Departments of Agriculture or Bureaus of Markets (Chapter 36).

Cross references are listed at the end of each of the three divisions. They point out sources of other information in Part II directly concerned with citrus and subtropical fruits or which is of possible value to those interested in these commodities. These references provide the basis for a more comprehensive picture of the Department's work with citrus and subtropical fruits.

Part I of the over-all report also contains a section which highlights some of the most important accomplishments of the Department in the fields of research, service and marketing education.

CITRUS FRUIT PRODUCTION, DISEASES, AND IMPROVEMENT
(BPISAE - b-2-1 Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To (1) develop and test production principles and methods, and varieties that will contribute to the sound development and economic stability of the citrus industry in the United States, and (2) answer some of the most pressing problems and needs of this rapidly changing industry. During the last decade, the U. S. Citrus industry has seen a large expansion in acreage and production, several very damaging freezes, a phenomenal increase in both the volume and proportion of fruit marketed either canned or as frozen concentrate, and has been ravaged (in California) or threatened by a serious virus disease affecting several common varieties on certain rootstocks. Thus the industry is continually faced with new problems and the need for new research to meet the changing conditions. Three major lines of work are currently being emphasized: (1) Disease identification and control, (2) development of improved varieties and rootstocks, and (3) development of new or improved cultural practices.

B. Currently Active Line Projects

b-2-1-1 - Breeding of citrus fruits to improve quality, production, hardiness, and disease resistance. The hybrids produced will be tested and selected with a view to obtaining varieties having certain juice qualities desired by the frozen concentrate or canned juice manufacturers. Others will be selected as more attractive varieties of better dessert quality for the fresh fruit trade.

b-2-1-2 - Factors affecting set of citrus in the Southeast. To determine the possibility of influencing fruit set and fruit drop by means of pollination studies, hormone sprays, and other treatments.

b-2-1-3 - Citrus propagation and rootstock investigations. Extensive field trials of a large number of citrus varieties and species as rootstocks are being conducted in Florida and Texas to obtain understocks better adapted to various soil conditions, more resistant to root and virus diseases, and producing higher yields of better quality fruit.

b-2-1-5 - The relation of cultural treatments and environmental factors to production of citrus on the irrigated soils of the Southwest. Several irrigation procedures are being compared with the objective of establishing principles on which to base improved irrigation practices for citrus growing in the desert regions of the Southwest.

b-2-1-6 - Fertilizer and soil management requirements of citrus. To secure fundamental information essential to the development of sounder, more economical fertilizer and soil management practices for citrus culture in the United States.

b-2-1-7 - Citrus tree diseases. To determine their cause and the factors governing infection and spread, and to devise and improve control measures. Most of this work is concerned with causes and control methods of rot-rot diseases of citrus, and the development of improved control measures for citrus melanose, a disease which disfigures the fruit and predisposes it to decay after harvest.

b-2-1-9 - Investigations of Tristeza disease. To develop information concerning the cause, method of transmission, susceptibility of various rootstocks and scion varieties, and possible control measures of a devastating disease of citrus in South America known as "Tristeza," and which is quite similar to a disease called "Quick Decline" in California. The work is being conducted in Campinas, Brazil, in cooperation with Brazilian scientists of the Instituto Agronomico.

C. History and Evolution of the Work

Work was begun by the United States Department of Agriculture on citrus diseases and breeding in Florida before 1900. During the early years it concerned mainly interspecies hybridization for improvement in color, flavor, and other qualities and the indentification of diseases and their causes with development of resistance and recommendations for their control. Bud selection studies for citrus fruit improvement were first started by the Department in California in 1909.

After World War I the citrus industry in Florida expanded rapidly on to new types of soil, and was beset with fertility problems. As a result, work was begun in 1926 on the fertilizer requirements of citrus. Similarly, growing irrigation problems in citrus orchards of California prompted the initiation of irrigation studies in California about 1936. More recently, the threat of the dreaded Tristeza disease of citrus in South American and other citrus growing countries caused the allocation of funds to study this disease in Campinas, Brazil, in cooperation with the Brazilian government, and to initiate "insurance" studies to test resistant stocks for commercial suitability in the United States.

D. Funds--Annual Expenditures

It is estimated that from before 1900 through World War I from $10,000 to $15,000 was spent annually for the disease and breeding investigations with citrus. After World War I about $30,000 a year was added for citrus canker research in Florida and variety improvement in California. Since that time certain projects have been completed and others undertaken as authorized to meet new problems and the growing needs of the industry, so that by 1950 the annual allotment for citrus production research had gradually increased to $101,520.

E. Examples of Outstanding Accomplishments

The development of a superior dessert quality group of citrus varieties known as "tangelos" by hybridization of grapefruit with tangerine, has resulted in the planting of considerable commercial acreage of such U.S.D.A. tangelo varieties as Thornton, Minneola, Seminole, and especially Orlando.

The selection of superior strains of common citrus varieties in California has been an outstanding achievement. In the past 25 years most of the new acreage planted in California utilized superior strains of Washington Navel and Valencia oranges, Marsh grapefruit, and Lisbon and Eureka lemons developed as a result of the bud selection work.

The determination of the cause and the development of practical control measures for several major citrus diseases. It was found that citrus scab and citrus melanose were caused by fungus organisms and the deleterious effect of these diseases on productivity and fruit appearance could be controlled by the timely application of copper-lime sprays. It was determined that citrus canker was caused by a bacterial organism, and that none of the usual control measures were effective. An extensive eradication campaign in cooperation with the affected Gulf States, was instituted and saved the industry from threatened destruction.

Basic work on the role of "trace" fertilizer elements in the nutrition of citrus is an outstanding chapter in the development of scientific agriculture. Studies in Florida contributed very materially to the development of fertilizer practices involving the use of mineral elements such as copper, boron, and manganese needed in minute amounts by all plants for healthy growth. These studies provided the key to profitable citrus production on the very sandy soils of the Ridge section of Florida, which now comprises more than 85 percent of the Florida citrus acreage. Without this knowledge of the need for and practical methods for applying these so-called "trace" fertilizer elements in citrus culture, the inherently very infertile cut-over "high-pine" lands in Florida would not have sustained over 300,000 acres of profitable citrus orchards which make up the principal agricultural enterprise of Florida.

Phosphate fertilizer trials in Florida orange orchards have demonstrated that the trees make little if any beneficial use of heavy phosphate applications. In 1948, when these findings were first made public, an estimated $2,500,000 was spent annually for the phosphate used in Florida citrus orchards. During the past two years the rate of use of this element in Florida citrus fertilizers has declined materially, resulting in a very appreciable saving to growers.

Tristeza disease of citrus in South America, which has destroyed practically all orchards on sour orange rootstock in that region and which threatens the industry in the United States, has been carefully studied by our workers, who have confirmed its virus causation and transmissability by budding and grafting and by a species of black citrus aphid. The susceptibility of practically all scion varieties and of several hundred potential rootstocks has been tested in Brazil. Growers in this country are now using resistant rootstocks in new plantings wherever soil conditions permit.

F. Some Additional Work Needed

Citrus breeding work needs to be expanded materially. The production of hardier and otherwise improved varieties better adapted to juice manufacture, and of better dessert quality is needed. Research in citrus breeding methods and techniques has progressed to the point that rapid progress would be possible with a moderate-scale breeding program.

Acceleration of research on the effects of fertilizer practices on juice quality and juice yield of citrus fruit is needed so that growers may more effectively and profitably produce fruit adapted to the requirements of the producers of frozen concentrate juice. This urgent need results from the spectacular development of this new method of processing and marketing citrus juices. Four years ago, less than 500,000 boxes of fruit were utilized for this product. Last year about 20,000,000 boxes, or one-third of the total Florida orange crop, was utilized for the manufacture of frozen concentrate orange juice.

A disease similar to or identical with Quick Decline or Tristeza disease of citrus has recently been identified in Louisiana. Research on this disease within our own boundaries is urgently needed before it spreads to our main citrus areas. The means of spread of infection in Louisiana need to be determined and also the feasibility of using possible non-virulent strains of the virus to protect trees against the virulent form.

TESTING OF CITRUS ROOTSTOCKS FOR RESISTANCE TO FOOT ROTS AND GUMMOSIS, TO SALINITY, AND TO NEMATODES

(BPISAE - RM:b-531 - Federal-State - RMA Funds)

A. Purpose and Nature of Current Work

The Tristeza disease of South America (discussed under work project b-2-1) makes it imperative that suitable citrus rootstocks be found to replace the widely-used sour orange which is susceptible to this virus disease. Tristeza resistance, however, is not the only requirement needed for a rootstock to qualify as a replacement for sour orange. In all citrus growing areas foot-rot and gummosis abound, and a successful stock must be resistant to these troubles and also should tolerate heavy, wet soils. In the Rio Grande Valley of Texas, a main citrus area, high salt content of the irrigation water and high boron content of the soils make it necessary that rootstocks for that area be also resistant to these factors. Thus the purpose of this project is to screen all potential rootstock material for tolerance to salt and boron and for resistance to footrots and nematodes. The work is conducted at Weslaco, Texas, in cooperation with the Texas Agricultural Experiment Station, and at Orlando, Florida.

B. Currently Active Line Projects

RM:b-531-1 - Tolerance of citrus rootstocks to salt and boron in the soil or irrigation water. Experiments are conducted in which large numbers of citrus rootstocks are subjected to graduated amounts of salt and boron, singly and in combination, and the effect on the citrus plants recorded.

RM:b-531-2 - Resistance of citrus rootstocks to footrots and nematodes. Footrots in this project include several organisms including Phytophthora footrot, Rio Grande gummosis, and cotton root-rot. Nematodes in some areas constitute a limiting factor for growth and production. Under this project rootstocks are tested for resistance to these organisms by inoculating the plants with the organisms and recording the results.

C. History and Evolution of This Work

Long-time observational data both in the United States and in other citrus producing areas have indicated that of the citrus species and varieties in general use as rootstocks the sour orange has been the most resistant to wet soil, foot rot, and gummosis. Its use also results generally in production of high quality fruit. Thus until the last decade, this stock was generally used in most parts of the world in the growing of oranges and grapefruit particularly when the plantings were on moderately heavy or wet soils.

About 1940 a disease began to sweep citrus plantings in South America, taking out all the trees on this rootstock. The same or a closely similar disease is now present in many citrus areas, including California and probably Louisiana. The disease is a virus and sour orange stock topworked with sweet orange or grapefruit is highly susceptible. Thus sour orange is no longer considered safe to use as a stock for citrus production. The other widely tested stocks that are resistant to the virus are known to be susceptible to foot rot and salt in the soil. It was therefore essential that an extensive program of testing the virus-resistant stocks for resistance to fungus diseases and salinity be established and pushed as rapidly as possible. This project was started July 1, 1949, at the recommendation of the Citrus Advisory Committee of RMA. Prior to that time no systematic research had been conducted on this problem.

D. Funds--Annual Expenditures

The allotment for the first year, 1950, was $18,000.

E. Examples of Outstanding Accomplishments

Although this project has been under way for only 1½ years, substantial progress has been made in establishing facilities and experimental plantings and in working out techniques. The first year's results indicate that one citrus rootstock, Cleopatra mandarin, which is resistant to Tristeza, is also somewhat more resistant to salt damage and nearly as tolerant to boron damage as sour orange. Citrus growers in Texas, who heretofore have used sour orange exclusively, are now turning to Cleopatra to a large extent. This is a move born of desperation for fear of an early invasion of Tristeza. We confidently expect to find more stocks that will be able to successfully replace sour orange.

F. Some Additional Work Needed

The threat of Tristeza virus and the lack of adequate information on suitable rootstocks constitutes one of the most serious problems facing the citrus industry today. While considerable work has been started on actual field trials of a number of citrus rootstocks, this phase of the work also should receive more attention. The stocks found suitable in resistance to Tristeza, foot rots, salt, boron, and other troubles, must prove themselves for vigor, productiveness, and high quality of fruits produced. This can only be determined by field trials over a number of years, conducted in all the important citrus growing areas, and with all important kinds and varieties of citrus fruits.

FRUIT FLY INVESTIGATIONS IN MEXICO
(BEPQ - No. I-a-2 - Federal-Mexican Government - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to (1) determine the potential danger to the citrus industry of the United States of the various fruit flies in Mexico or in the Rio Grande Valley of Texas and (2) develop methods of controlling the species that are already serious pests or that may become so. Current work includes (1) a study of the biology and habits of the species involved as a basis for estimating their potential danger as pests and the development of control measures, (2) the development and improvement of methods for destroying maggots and eggs of fruit flies in fruits to permit movement of the fruit to markets throughout the United States without danger of spreading injurious species, and (3) the development of methods of field control of Mexican fruit flies of importance to the citrus industry in the United States.

B. Currently Active Line Projects

I-a-2-1 - Treatment of products infested by fruit flies. To perfect and improve the vapor-heat method of treatment, by the commercial use of which products that may be infested can enter normal channels of trade with perfect safety to the fruit-producing industries of the country.

I-a-2-2 - Zoning the United States on relative danger from fruit flies. To determine the zones in the United States in which different Mexican fruit fly species would not be continuing economic factors if they reached those areas.

I-a-2-3 - Investigations on DDT as a field control for the Mexican fruit fly. To develop a spray that will commercially control this fruit fly and to establish evidence that the formula adopted will not affect trees, fruit or fruit by-products adversely.

I-a-2-4 - Exploratory laboratory and field investigations with new insecticides for fruit flies. To determine the possible value of the newer insecticides against fruit flies, and to select those showing promise for more intensive study.

C. History and Evolution of This Work

The Mexican fruit fly, which attacks citrus, mangos, peaches, apples, and other fruits, gained access to the growing Texas citrus industry in 1927. This made it necessary to restrict production and marketing of citrus in that area to protect the rest of the country from invasion by this insect. Eradication of the pest in Texas was undertaken. However, it was soon found that the fly practically disappeared from Texas orchards during the summer months and that new ones flew in during the fall or winter from various points in northern Mexico. The hope of eradication, therefore, had to be abandoned.

In order to secure basic information on this insect and to develop methods of treating oranges and grapefruit to eliminate the danger of shipping the fruit fly to other parts of the country, and to develop methods whereby individual growers could control the pest if it should become abundant enough to cause serious damage, arrangements were made to carry on work in Mexico, in cooperation with the Mexican Government. A laboratory was accordingly established in Mexico City in 1928. The Mexican authorities have been most cooperative. Realizing that knowledge of fruit flies would be valuable to Mexico, the Mexican Government built extensive laboratories specifically for the work, providing them entirely without cost.

The work has also included studies of the numerous other species of fruit flies that exist in Mexico, as there has been opportunity. Many of them were new to science at the time the work was undertaken and are potential threats to agriculture in the southern United States.

D. Funds-- Annual Expenditures

Annual expenditures for fruit fly work in Mexico were about $30,000 in the early years, $22,000 in fiscal year 1934, and increased to a high point of $52,300 in 1948. Expenditures for the fiscal year 1950 were about $49,200.

E. Examples of Outstanding Accomplishments

Methods developed that permit safe movement of fruit to uninfested areas. A method of treating the fruit by means of vapor-heat was developed to permit the movement of fruit to uninfested areas without danger of establishing the Mexican fruit fly in such areas. This permitted the citrus industry to continue shipments through the entire normal shipping season, and to all markets instead of to specified markets in the north where establishment of the fruit fly would be unlikely. In some seasons as much as 150,000 tons of citrus fruit have been given the vapor-heat treatment.

Effective fruit fly traps useful in many ways. The laboratory in Mexico has worked out lures that attract different fruit flies and a most effective trap in which to use them. The fruit fly that has affected the Texas citrus industry migrates northward each year from large wild areas in Mexico. Trap lines from these areas to Texas established the fact. Traps throughout southern Texas show each year when the flies begin to arrive, how many are coming in, and how large the treatment job will probably be. Traps are used extensively in survey work, and serve as a means to determine whether a fruit fly has gained access to a new fegion.

Potential status of Mexican fruit fly in different climates determined. The Mexican laboratory invented apparatus with which it is possible to reproduce in the laboratory weather conditions recorded elsewhere. In this apparatus populations of fruit flies have been subjected to the cold winters or hot summers of selected U.S. fruit regions to learn if they would be serious pests in those regions should they get there. In this way it has been determined that establishment of the Mexican fruit fly in most of the northern fruit producing areas of the United States is virtually impossible.

Valuable information on many fruit flies accumulated. Investigations in Mexico have also dealt with a number of species other than the Mexican fruit fly. Many of these would be serious pests if they should accidently find their way into the United States. Basic information on them would be of great value to the fruit industries of the southern United States if this should occur. In fact, the fundamental information secured has already aided in connection with fruit fly problems elsewhere.

F. Some Additional Work Needed

Further improvement of the vapor-heat process needed. Although the vapor-heat process as now authorized is being used whenever necessary to permit fruit to move from fruit fly infested areas to uninfested ones, further improvement is very much needed. It is hoped that the exposure period can be further shortened, which would permit more frequent turnover and more efficient use of equipment.

Better lures needed for fruit flies. Although lures are available that attract and catch large numbers of certain kinds of fruit flies, better and more attractive materials are needed, as well as materials that would attract species that do not come to present baits. Intensification of this work is very much needed.

Studies of other fruit flies needed. There are numerous species of fruit flies, all of potential serious economic importance, about which comparatively little is known. The work dealing with these fruit flies should be expanded and more complete information secured. The information needed includes the food plants, distribution range, the conditions under which these insects thrive and methods of controlling them.

FRUIT FLY INVESTIGATIONS IN THE CANAL ZONE
(BEPQ - No. I-a-3 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

To gather as much information as possible on the biology and food plants of the many species of fruit flies present in Central America. This is an area in which probably the greatest number of fruit flies occur, since it includes over-lapping distribution for many northern and southern forms. Currently, this information is secured for its value when any of these fruit flies become of importance in other areas.

B. Currently Active Line Projects

I-a-3-1 - Identity and biology of fruit flies in Central America. To obtain information of a preliminary nature on the habits of different fruit flies, the kinds of fruits each species attacks, the stage of the fruit when attacked, the length of life in the fruits, and other useful data.

I-a-3-2 - Relative abundance and importance of various fruit flies in Central America. To learn what species of fruit flies occur in different types of plantings or growths, the times when they are abundant, to determine how the populations move, how the species fluctuate under different conditions, and related data.

C. History and Evolution of This Work

Studies of fruit flies in the Canal Zone have been under way since the early twenties. The laboratory maintained there is a small outpost. By means of traps and the rearing of flies from infested fruits, information is gathered on the different species present or that move into the region, their seasonal abundance, type of location they prefer, and kind of fruit attacked. This information has on several occasions proved very valuable and will in the future be of value whenever any of these species assume economic importance elsewhere. Only part of the time of the entomologist in charge can be devoted to the fruit fly work, since he is also called on in connection with other entomological problems in the Canal Zone.

D. Funds-- Annual Expenditures

By decades the average annual expenditures in the Canal Zone have been about as follows: 1921-30 $3500, 1931-40 $5800, 1941-50 $9300. The estimated expenditures for 1950 were about $8900.

E. Examples of Outstanding Accomplishments

Important information secured about many kinds of fruit flies. In all, 68 species of fruit flies have been recorded in the Canal Zone. More or less detailed biological information has been secured for at least 23 of these species, including their behavior and the kinds of fruit they attack. With many species the only information available is the fact of capture in bait traps.

F. Some Additional Work Needed

Intensification of the biological studies desirable. Since very little is known about many of the fruit fly species that have been taken in the Canal Zone and since most of these are of potential importance if they should find their way into commercial fruit-producing areas, intensification of the studies on them is very much needed.

CITRUS BLACKFLY INVESTIGATIONS
(BEPQ - No. I-a-4 - Federal-Mexican Government - Regular Funds)

A. Purpose and Nature of Current Work

To (1) determine where the citrus blackfly occurs in Northern Mexico; (2) perfect methods for its commercial control or eradication; (3) determine whether present control methods can be used effectively to eradicate incipient infestations; and (4) gain experience in the development of control or eradication programs in the event that this pest should be found in the United States. The citrus blackfly is a destructive pest of Asiatic origin that is doing great damage to citrus in Mexico, and that is threatening to invade the citrus production areas in the United States. Currently, the work is carried on in Mexico in cooperation with Mexican officials. It includes (1) surveys to determine where the insect occurs in areas of Northern Mexico as a possible threat of spread to the United States, (2) the development of insecticides that may be used for commercial control or eradication of the pest, and (3) the establishment in Mexico of parasites secured from other areas, which may aid in reducing blackfly infestations.

B. Currently Active Line Projects

I-a-4-1 - Observations on spread of the blackfly and on the effectiveness of its parasites. To gain knowledge on movement of the blackfly, especially in the direction of the United States, and to determine the effectiveness of parasites in its control.

I-a-4-2 - Investigations of rotenone in oils as a commercial control for the citrus blackfly. To perfect a satisfactory commercial control for the citrus blackfly for use in Mexico to forestall its further northward movement, and to have it available should it be needed in the United States.

I-a-4-3 - Food plants of the citrus blackfly in Mexico. To learn what trees or plants the blackfly will infest in the Western Hemisphere, in order to know what trees and plants would have to be included in any eradication program.

I-a-4-4 - Exploratory studies of the newer insecticides for citrus blackfly. To make exploratory field tests of new insecticides against the citrus blackfly, and to select the most promising materials for more concentrated study.

I-a-4-5 - Importation of natural enemies from Cuba, Malaya and India into Mexico. To introduce into Mexico from these areas effective natural enemies likely to aid in reducing infestations of the citrus blackfly, and thus lessen the risk of entry of the pest into the United States.

I-a-4-6 - Rearing, colonization and studies on effectiveness of natural enemies in Mexico. To effect establishment and spread in Mexico of various parasites of the blackfly, and to study their effectiveness in controlling the pest.

I-a-4-7 - Investigations of large-scale spraying for control of citrus blackfly in Northeast Mexico. To carry on large-scale experiments in northeastern Mexico with the best available insecticides to determine whether their use in an eradication program would be feasible; also, to gain practical experience with the problems likely to be met in eradication programs.

I-a-4-8 - Investigations of large-scale spraying for control of citrus blackfly in Northwest Mexico. This work is similar to that carried on under I-a-4-7, except that it is done in northwestern Mexico, where conditions are totally different.

I-a-4-9 - Studies of the biology of the citrus blackfly and the development of traps for use in survey work. To study the life history and habits of the insect in order to gain information that would be useful in the development of control measures; also to develop more efficient traps for use in surveys to determine how far the insect has spread.

C. History and Evolution of This Work

The citrus blackfly, which is perhaps the worst insect pest of citrus, is of oriental origin. It attacks the leaves of citrus trees and prevents the development of marketable fruit under conditions of heavy infestation. This blackfly reached the Western Hemisphere in 1913, when it invaded the West Indies and Central America. From 1917 to 1923, studies were made of this insect in Panama, with special emphasis on its biology and seasonal history. In the early thirties a parasite from Malaya was introduced into the West Indies and proved to be of great value in keeping the pest within bounds. This is discussed in more detail under project No. I-k-1, "Collection and Importation of Natural Enemies of Insect Pests and Weeds." Two or three years later the blackfly was found in Key West, Florida, but was eradicated through a cooperative Federal-State program. About 1935, the pest reached the West Coast of Mexico and within a few years had spread to many scattered localities in that country. The parasite that had been so successful in the West Indies was introduced into Mexico, but conditions there prevented it from being fully effective. The continued spread of the blackfly northward alarmed the citrus growers in southern United States, and in 1947 California grower organizations undertook a spray program in western Mexico to prevent further northward spread. Early in the summer of 1948, Federal funds were made available for extensive work for the purpose of (1) developing more effective insecticides, (2) determining the possibility of eradication of isolated infestations, and (3) exploring further the possibility of parasite control. Previous to the allocation of these funds, more or less work had been done by the Department laboratory in Mexico City, incidental to other work on this problem. All of this work is carried on in cooperation with the Mexican Government.

D. Funds— Annual Expenditures

The cost of the earlier work which was under way in 1917 to 1923 was about $2,000 to $4,000 a year, although exact figures are not available. No estimate is available on the actual cost of the incidental work carried on through 1947, but it may have been as great as $8,000 in some years. During the fiscal year 1949, the total obligations were about $81,000, the major part of which was expended for large scale experiments on control and experimental eradication. Expenditures in 1950 were about $170,000, including $65,000 for experiments in control and eradication, $20,000 for the introduction and establishment of parasites, $20,000 for studies of biology and the development of traps for use in survey work, and $75,000 for survey work in northern Mexico and southern United States. Federal contributions to the successful eradication project in Florida amounted to $36,000.

E. Examples of Outstanding Accomplishments

Surveys delimit areas to be treated by Mexican officials. Surveys, conducted in cooperation with Mexican officials, have brought to light incipient infestations of the citrus blackfly at numerous points in northern Mexico, the most serious of which was in the city of Matamoros, directly across the Rio Grande from Brownsville, Texas. All these infestations were on or near the main highways leading north and on a direct line to the citrus producing area of Texas. Locating these infestations while only limited areas were involved has permitted effective control which greatly retarded if not prevented further northward spread.

Effective spray formulas developed. Two spray formulas have been developed which are highly effective against the citrus blackfly. One contains oil and ground cube root, and the other a mixture of kerosene-xylene and DDT. These have given effective commercial control and have also been used successfully to eradicate isolated infestations. However, these mixtures sometimes cause injury to citrus trees, and safer materials are needed.

Traps devised for blackfly survey. An effective trap, involving the principle of a sticky board, has been developed that captures tremendous numbers of the blackflies when exposed in trees in the orchard. This trap will be of great value in conducting survey work to determine the distribution and spread of the insect.

Parasite introduction has already given promising results. Certain of the parasites imported into Mexico from the drier parts of Asia look very promising against the citrus blackfly. In fact, they are well established at the points at which they were liberated and it has already been possible to collect large numbers at early points of introduction for use in establishing the species in other localities.

F. Some Additional Work Needed

Continuation and strengthening of survey essential. Inspections must be continued and intensified to locate incipient blackfly infestations so that they may be prevented from becoming established in areas immediately adjacent to or within the United States. Any infestation of the citrus blackfly in the northern part of Mexico is a serious and direct threat to the production of citrus in the United States.

Intensification of the work with insecticides needed. Although effective control of the blackfly may be secured by the use of insecticides now available, injury to the trees sometimes occurs. Safer and even more effective insecticides are therefore much needed, and extensive work along this line, including the testing of numerous new materials now available, is very desirable.

Further parasite introduction and distribution needed. In order to reduce the threat to American agriculture resulting from the occurrence of the citrus blackfly in Mexico, full advantage should be taken of all possible natural enemies. Stocks of as many kinds of parasites as possible should be brought in and these distributed to many parts of Mexico. This would reduce the hazard of northward spread of the blackfly and would also provide a nearby source of parasite material if an infestation should be found in the United States. Mexican horticulture would, of course, benefit, but such benefit would be incidental to the main objectives.

INVESTIGATIONS OF CITRUS AND OTHER SUBTROPICAL FRUIT INSECTS
(BEPQ - No. I-b-9 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of the activities under this work project are to develop more effective and economical methods of controlling the numerous insect and mite pests that attack citrus and other subtropical fruits. These insects form a major item of production costs. Currently, the nature of the work is to (1) determine the conditions that may have brought about resistance of California red scale to cyanide fumigation, and to develop methods of controlling it in spite of this resistance, (2) develop the use of parathion or related materials, alone or with oils, for control of various scale insects on citrus, (3) determine the value of other new insecticides as substitutes for or supplements to oil sprays or fumigation, and (4) obtain information on the biology and habits of various insects and mites attacking citrus and other subtropical fruits such as mango, avocado, guava, papaya, and pineapple, and to develop control measures for these pests.

B. Currently Active Line Projects

I-b-9-1 - Investigations of insecticides for the control of the citrus red mite. To develop means of controlling the citrus red mite that will not injure citrus trees or adversely affect the fruit.

I-b-9-2 - Influence of temperature and humidity on the abundance of the citrus rust mite. To determine the effect of different temperatures and humidities and combinations of them on the citrus rust mite, as a basis for a possible explanation of the seasonal slumps in populations that occur naturally in citrus groves.

I-b-9-3 - Development of insecticides that can be used with oil to control the citrus rust mite. To develop a combination oil spray that can be used to control both rust mites and scale insects with one application, without injuring the trees or fruit.

I-b-9-4 - Studies of the timing of oil spray applications for the control of scale insects. To determine whether application of an oil spray early in the summer will give more effective control of the Florida red and purple scales than one in October, and whether a single application at one time or the other will give satisfactory control of moderately heavy infestations.

I-b-9-5 - Studies of factors influencing increases in scale insects and whiteflies following the use of sprays leaving heavy deposits. To determine whether the marked increases of scales and other insects that occur following applications of zinc sulfate as a nutritional spray can be avoided by applying this material to the soil under the trees and without impairing its beneficial effects.

I-b-9-6 - Studies of influence of varying vigor of citrus trees resulting from variations in the use of nutritional sprays, fertilizer treatment, and orchard practices on scale populations. To determine whether variations in the vigor of citrus trees resulting from variations in the use of nutritional sprays, fertilizer treatment, and orchard practices result in differences in scale insect populations.

I-b-9-7 - Investigations of insecticides for control of the papaya fruitfly. To develop more effective and practical insecticides for controlling the papaya fruitfly.

I-b-9-8 - Investigations on control of the little fire ant, grasshoppers and stinkbugs with insecticides. To (1) determine the formulation of DDT and method of applying it that will give the highest practical degree of control of the little fire ant, (2) test other promising new insecticides in comparison with DDT for use to control this pest, and (3) develop a combination program of control of the little fire ant, grasshoppers, and stinkbugs in citrus groves.

I-b-9-9 - Studies of control of the pineapple mealybug. To develop a more effective control of the pineapple mealybug than the oil spray now in use.

I-b-9-10 - Studies of the biology of the purple scale. To complete and round out the records on the biology of the purple scale in the laboratory files, with special reference to the additional information needed to aid in timing spray applications.

I-b-9-11 - Studies of the biology of the Glover scale on citrus in Florida. To obtain information supplementing that now available on the seasonal history, periods of peak infestation, and reproductive capacity of the Glover scale, to provide a better basis for timing spray applications.

I-b-9-12 - Studies on the control of insects and mites on citrus nursery plants by fumigation with methyl bromide. To (1) determine the value of controlling the insects and mites on citrus nursery stock as a means of postponing infestations in new groves, (2) determine the limits of tolerance of citrus nursery stock to methyl bromide, and (3) develop effective schedules of methyl bromide fumigation of citrus nursery stock.

I-b-9-13 - Studies of miscellaneous insects attacking citrus and other subtropical fruits, with special reference to insects affecting mango, guava, papaya, and avocado. To obtain information on the biology and habits of miscellaneous insects and mites attacking citrus and other subtropical fruits as a basis for the development and application of control measures.

I-b-9-15 - Laboratory studies on the effect of repeated fumigations in building up resistance of the California red scale to HCN and the stability of stocks when fumigation is discontinued. To (1) determine further the effect of repeated fumigations with HCN on resistance of stocks of the California red scale and the effect of discontinuance of fumigation on stocks that have already acquired a degree of resistance, and (2) secure a measure of the ultimate effect on control practices as a basis for the development of improved control measures.

I-b-9-17 - Investigations on plastic-coated fabrics for gastight fumigation tents. To develop improved, pliable, light-weight, longer-lived gastight tents.

I-b-9-18 - Development of gas evacuator equipment.--Tests of methods of reducing operational hazards in gastight tent fumigation. To develop a simple, rapid, and efficient method of ridding work areas of residual HCN gas for the protection of operators.

I-b-9-19 - Laboratory tests of gases other than HCN against California red scale. To determine the value of promising new fumigants for control of the California red scale.

I-b-9-21 - Studies on the influence of emulsifiers and other spray components on the effectiveness of sprays of derris and cube resins in oil for control of California red scale. To determine the factors responsible for variation in the results obtained with derris or cube resins with oil in control of the California red scale.

I-b-9-22 - Tests of materials other than derris or cube resins as additives to or substitutes for oil against scale insects on citrus. To find and develop materials, other than derris and cube resins, which are effective in the control of scale insects on citrus, used either alone or in combination with oil.

I-b-9-24 - Investigations of thrips on citrus, with special reference to the development of resistance to insecticides. To (1) determine the factors contributing to the development of resistance of the citrus thrips to insecticides recommended for its control, as a basis for devising ways and means of preventing or overcoming such development, and (2) find and develop other insecticides as possible substitutes for presently recommended materials.

I-b-9-25 - Investigations on effectiveness of parathion against scale insects on citrus. To determine the possibilities of parathion as a practical control of various scale insects on citrus.

C. History and Evolution of This Work

Serious work on citrus and other subtropical fruit insects in the Department started in the early eighties, when an agent of the newly created Division of Entomology spent about half his time in a study of citrus insects in Florida. This study resulted in the publication of a classic book of 227 pages on the subject. Field agents maintained in California from 1886 to 1894 worked on biological control (to be reported under another project) and fumigation for citrus scale insects. Little attention was paid to insects attacking citrus from 1894 until 1905. Serious damage by citrus white flies in Florida in 1906 caused the Congress to appropriate funds for work there. The following year field work in California was resumed, the main project being the fumigation of citrus for scale insects and the control of citrus thrips. Continuous investigations of citrus insects have been carried on in both areas since that time, with some incidental work in Louisiana. In California the major problems have been the California red scale, which has exhibited increasing resistance to hydrocyanic acid fumigation. Other scale insects and the citrus thrips have also been studied in California. In Florida, most of the work has dealt with a wide range of scale insects, white flies and mealybugs. In 1929 and 1930 most of the work in Florida dealt with the Mediterranean fruit fly, which had established itself there after being introduced accidentally. From time to time studies have also been made in Florida of the numerous insects affecting other tropical or subtropical fruits such as the mango, avocado, papaya and pineapple. Work was also done with date palm insects in southern Californi including a project to eradicate the date scale.

D. Funds--Annual Expenditures

Accurate information on expenditures prior to 1907 is lacking. From 1880 to 1894 they probably ranged from $1,000 to $5,000 annually. Before this period and between this period and 1906 the expenditures were nominal, perhaps a few hundred dollars a year. The expenditures in 1907 were about $4,700. The average expenditures by decades, (exclusive of work on the date scale and tropical fruit flies) have since been about as follows: 1911-1920: $17,000; 1921-1930: $25,000; 1931-1940: $44,000; 1941-1950: $48,000. The allotment for 1950 was about $56,000. The total amount expended by the Federal government for date scale eradication totaled approximately $500,000 in fiscal years 1921 to 1936, and for eradication of the Mediterranean fruit fly totaled slightly more than $6,600,000 in fiscal years 1929 to 1932.

E. Examples of Outstanding Accomplishments

Oil sprays developed. Kerosene emulsion, the first practical contact insecticide, was devised by a Department worker in Florida about 1881. For many years kerosene emulsion was the standard contact spray and was used very extensively. The heavier fractions of oil, however, were found by Department workers to be safer and more effective. These sprays give good control of scale insects, although under certain conditions there is an unfavorable effect on the tree. Citrus growers now use millions of gallons of the oil sprays annually.

Hydrocyanic acid fumigation developed for control of California red scale. The first fumigation of citrus trees under tents with hydrocyanic acid was carried on by a Department worker in 1887. Department workers also later developed methods of marking the tents to determine the volume of each tree to be treated and worked out tables of dosages to determine the quantities of cyanide needed. This method was found to be highly effective under most conditions, and permitted growers to secure adequate control of the scale. However, in some areas the scale insects subsequently became resistant to the action of cyanide.

Mediterranean fruit fly eradicated in Florida. The eradication of the Mediterranean fruit fly in Florida by entomologists of the Department and State agencies was a service of inestimable value to farmers throughout our southern tier of States. This fruit fly is a major pest of citrus, and many other fruit crops, in tropical and subtropical areas in many parts of the world. The first Mediterranean fruit fly infestation in the United States was found near Orlando early in 1929. The infested area embraced nearly 16,000 square miles. Approximately 120,000 acres of citrus and 160,000 acres of other fruits and vegetables were located in the area. Because of the fly's destructive habits, an eradication program was undertaken immediately in cooperation with State agencies. Drastic restrictions were placed on the growing of fruits and vegetables that would ripen between May 1 and October 1, thus depriving the fly of suitable places where it could develop. Poisoned bait sprays were applied to the foliage of wild and cultivated plants at regular intervals, sometimes to as many as 110,000 acres in one week. The last living fly was seen on July 25, 1930, only a little more than a year after the infestation was discovered. The prompt elimination of the fly was an achievement without parallel in entomological history.

Parlatoria date scale eradicated. The eradication of the Parlatoria date scale in the United States was another outstanding accomplishment of Department entomologists working cooperatively with State organizations. This successful effort relieved date growers in the Southwest of a serious pest which is capable of causing severe crop losses. The Parlatoria date scale had become established in Arizona and California late in the nineteenth century, after having been accidentally introduced on imported palm shoots. The seriousness of the injury caused by the scale was soon recognized and efforts to eradicate it were made as early as 1907. In 1929 the eradication effort was intensified. The number of infested palms had been reduced from several thousand to only three by 1934. These were successfully treated and no Parlatoria date scales have since been found in the date producing areas of the southwest.

Basic information secured on resistance of California red scale to hydrocyanic acid fumigation. The development of resistance to fumigation on the part of the California red scale has been studied and much basic information has been secured. Scale stocks maintained in the laboratory have been given more than 40 repeated fumigations at dosages low enough to allow some of the insects to survive. Resistance to cyanide built up rapidly at first, and has continued to increase at a slower rate. It now takes three times as much cyanide to kill these scales as at first. Once built up the resistance seems to be retained. All of this work points to the need for a new insecticide for red scale control, and has a definite influence on the planning of further investigations. A number of practical growers, realizing the situation, have already changed from fumigation to spraying with oil.

Effective methods worked out for rust mite control. The early Federal entomologists working on citrus problems in Florida found that sulfur is effective in controlling the citrus rust mite. From time to time the entomologists have developed improvements in the formulations used, but the basic material has remained the same. This work has given the growers a cheap, effective means of controlling this pest.

Parathion found effective in control of citrus scale insects. Parathion has been found to be effective in controlling the California red scale, especially when used in a small quantity of a light mineral oil. If means of preventing foliage injury that sometimes occurs can be worked out, parathion may replace both fumigation and oil sprays. Neither of these are always satisfactory. Parathion has also been used very effectively against several scale insects in Florida. It has not caused injury there. It improves the quality of the fruit instead of reducing it, as the oil sprays sometimes do at certain times of the year. Parathion, unfortunately, is a dangerous material to use. With adequate precautions it should be possible to use it safely. In any event, the use of parathion may point the way to some similar material that is safer to use.

Studies made of insects affecting avocado and mango in Florida provide basis for control. Detailed studies were made in the early twenties of the biology of the more important insects affecting the avocado and mango in Florida, and control methods worked out, The information already obtained has beenvery useful to growers of these fruits. It will also form the basis of further studies dealing with the new insecticides and newer methods of control.

Little fire ant controlled in Florida citrus groves. Department workers have found that spraying the trunk and lower branches of the trees with DDT, chlordane or toxaphene practically eliminates the little fire ant. This insect is an extremely annoying one. When fire ants begin to sting workers in a citrus grove, the entire crew will often walk out and refuse to work there anymore. Controlling the fire ant removes one cause of labor troubles, and permits normal harvesting and other orchard operations to go on without any trouble.

Rotenone materials add to effectiveness of oil sprays. Department workers in California found that the addition of derris resins or other rotenone-bearing materials to oil sprays materially increases the kill of California red scale. Such combinations have been used to some extent in California and are now being used against citrus black fly in Mexico, The latter insect is a serious threat to the citrus industry of the United States but has not yet been found north of Mexico (except for a small infestation in Key West, which was eradicated in the middle thirties.)

Argentine ant controlled in citrus groves. An effective poison syrup and simple methods of using it to control the Argentine ant were devised many years ago by Department workers. This ant is common in citrus groves, both in the Gulf region andin parts of California. It is a general nuisance, and is serious in citrus orchards because it cares for and protects a number of scale insects and mealybugs from their natural enemies. Infestation by these insects is always worse when this ant is present. The development of this method of control gave the growers a simple, effective, and inexpensive means of dealing with the Argentine ant problem.

F. Some Additional Work Needed

Further work needed with parathion and closely related materials for citrus scale insect control. The outstanding results obtained with parathion in citrus scale insect control offer promise for the first time that it may be possible to get away from oil sprays and fumigation. The work with parathion and related compounds should be pushed as rapidly as possible in order that there may be developed a material that will give adequate control without undue hazard to the operator, which is the most serious shortcoming of parathion.

Studies of insect problems in Rio Grande Valley citrus orchards needed. Apparently because of a favorable condition affecting parasites and other natural enemies, citrus insect problems in the Rio Grande Valley have been much less serious than in other producing areas. A study of this situation is needed, since the information obtained could be useful in other areas where growers are now spending large amounts of money in keeping insect pests within bounds. With some modification of orchard practices, it might be possible to increase the effectiveness of these natural enemies.

New insecticides needed for citrus thrips. Tartar emetic, an effective material used for controlling citrus thrips suddenly became ineffective after two seasons, apparently because the insect had quickly developed a resistance to it. The use of DDT, another effective material, was followed by outbreaks of pests formerly controlled by their natural enemies. Further studies are needed of the numerous new insecticides that are becoming available in order that adequate effective control measures may be available to growers.

More extensive studies needed of insects affecting tropical fruits other than citrus. The various tropical fruits such as avocado, mango, guava, papaya, and pineapple should receive much more attention than they are being given at the present time. Although much information on the biology of these pests is already available, information on control measures goes out of date rapidly with the introduction of newer insecticides. All of these should be thoroughly tested in order that their value in pest control on these fruits may be determined and in order to give the grower as wide a range of insecticides to choose from as possible.

Better control measures needed for citrus red mite and bud mite. The citrus red mite and citrus bud mite are not readily controlled with parathion and some of the other newer insecticides that have been recently introduced. Further experiments are needed with other insecticides in order that the grower may have the best possible means of controlling these pests.

BIOLOGY AND ECOLOGY OF THE ORIENTAL FRUIT FLY

(BEPQ - No. I-o-1 - Federal-State-Territory - Regular Funds)

A. Purpose and Nature of Current Work

This project is designed to determine the effect of climate and weather on the Oriental fruit fly, a serious agricultural insect pest that recently became established in the Hawaiian Islands and thereby evaluate the possibility of survival of the fly on the United States mainland. Investigations now under way utilize the great mountain masses on the islands of Maui and Hawaii to study the behavior and life history of the insect from tropical sea level to the wind-swept temperate zone altitudes. The detailed biology and behavior of the insect is also being studied under controlled conditions in the laboratory. Newly designed equipment will permit the duplication of the temperature and humidity conditions of many sections of the United States mainland so that a direct check will be available on the ability of the insect to survive in those locations.

B. Currently Active Line Projects

I-o-1-1 - Effect of temperature and humidity on the oriental fruit fly under controlled conditions. To determine the effect of controlled fluctuating and constant temperatures and humidities on the development, activity and length of life of the various stages of the oriental fruit fly.

I-o-1-2 - Effect of climate on the oriental fruit fly under field conditions. To determine the effects of climate on the oriental fruit fly under natural conditions.

I-o-1-3 - Miscellaneous biological studies. To secure information on the phases of the seasonal history and habits of the oriental fruit fly not covered by other line projects.

I-o-1-4 - Hosts of the oriental fruit fly. To determine what fruits and vegetables the oriental fruit fly will breed in, what fruits are important in maintaining high fly populations naturally, and the effect of various physical factors of fruits and soil on the development of the various stages of the oriental fruit fly.

I-o-1-5 - Population trends of the oriental fruit fly. To correlate the fluctuation of fly population with time of fruit ripening, and climate studies in an attempt to correctly evaluate the influence of various fruits and critical climatic factors on fruit fly abundance. (Work in part under contract with private organization.)

I-o-1-6 - Migration and movement studies of the oriental fruit fly. To make fundamental investigations on migration and movement of the oriental fruit fly, including probable direction and rate of movement and the effect of wind and other climatic factors. (Work in part under contract with private organization.)

C. History and Evolution of This Work

When the fly first appeared in Hawaii in 1946, Territorial agencies initiated simple experiments on the relation of the fly to the climate of high altitudes. The present project was initiated on July 1, 1949, and expanded that work in view of its significance to mainland agriculture. A full knowledge of the fly in relation to weather, host fruits, parasites and predators is absolutely essential to a complete understanding of the economic problem and its control.

D. Funds-- Annual Expenditures

The 1950 fiscal year expenditure was about $156,300.

E. Examples of Outstanding Accomplishments

Hawaiian orchid industry saved. The rapidly developing orchid industry in Hawaii was brought practically to a standstill by the advent of the oriental fruit fly to the Islands and the resulting embargoes on shipments. A very careful biological study of the fly in relation to its ability to attack the commercial flower showed that there was no risk involved, and it was thus possible to permit normal shipment. The results of this study has not only saved an important Hawaiian industry but has provided a great stimulus to its future development.

Fly shown to live 12 months in temperate climate. The fly has lived for a year in temperate zones on the mountain slopes where freezing temperatures occurred and where the climate in many respects approximates that of many mainland areas. This would seem to indicate that many mainland agricultural areas are in jeopardy.

Citrus fruits shown poor hosts for fly. It has been determined that the oriental fruit fly does not develop in large numbers in citrus fruits in the Hawaiian Islands, but at higher elevations deciduous fruits such as loquat, apricot and peach, permit the development of hugh fly populations.

Many California fruits found susceptible. Large numbers of California fruits have been tested as fly hosts, as an essential preliminary to the proper evaluation of the importance of an infestation, should it reach the United States mainland. Many susceptible fruits have been found.

Migratory habits of fly proven. Studies have demonstrated that the oriental fruit fly has migratory habits that will greatly complicate quarantine and control measures in the event of a mainland infestation. It has crossed an ocean strait 9 miles wide; it has been recovered 20 miles from a release point; it can be carried on the outside of fast moving vehicles, and it has been observed to drift back and forth over large areas.

F. Some Additional Work Needed

This project has been organized so recently that new research will not be suggested at this time. However, the following current work should be given special emphasis.

Climatic studies must be extended. It is essential that climatic studies in the field stations be continued until comparisons between seasons can be obtained and evaluated.

Bioclimatic cabinets required to simulate field conditions. Since it is impossible to study the fly in mainland areas, it is necessary to bring the temperature and humidity conditions of these areas to Hawaii to test the ability of the fly to survive under those conditions. Development of special equipment necessary to accomplish this purpose is necessary. Weather data has been assembled from all the critical areas on the United States mainland and these will be duplicated and the biology of the fly studied in the cabinets.

BIOLOGICAL CONTROL OF THE ORIENTAL FRUIT FLY
(BEPQ - No. I-o-2 - Federal-State-Territory - Regular Funds.)

A. Purpose and Nature of Current Work

The purpose of this work is to find and establish insect parasites and predators that may aid in the control of the oriental fruit fly, which is a most serious threat to fruit production in the Hawaiian Islands and the United States. The tropical areas of the World are being combed for parasites and predators of the insect. The search in some of these areas already has been completed. Entomological explorers are now pushing forward into new and untried hunting grounds. In cooperation with State and other agencies, explorers have been sent to Malaya, Australia, New Caledonia, Africa, India, South China, Formosa, Southern Philippines and Thailand, and are at present in North India, South India, Africa, Thailand, Philippine Islands and New Caledonia. When such insects are found, they are reared in quantity, and then forwarded to our laboratories on Oahu. The reception and handling of the parasite material in Hawaii, and also the trips made to certain other areas to secure parasites, are financed with regular funds. Expeditions to certain other areas are carried on with RMA funds (See statement on BEPQ No. RM-b.264, Importation of Natural Enemies of Fruit Flies.) Other expeditions are financed by cooperating agencies.

B. Currently Active Line Projects

I-o-2-1 - Reception of fruit-fly natural enemies. To receive and rear under strict quarantine all incoming shipments of fruit-fly material from foreign countries.

I-o-2-2 - Breeding tests with introduced fruit-fly natural enemies. To test all introduced natural enemies for their ability to develop on the oriental fruit fly and other fruit flies in Hawaii, and to establish colonies of the successful species for subsequent breeding and liberation.

I-o-2-3 - Biological studies of fruit-fly natural enemies. To conduct breeding, life history, and biological studies of the introduced species as may be necessary or desirable for their complete utilization in the biological control program.

I-o-2-4 - Fruit-fly parasite exploration. To secure as many natural enemies of fruit flies as possible and bring them into Hawaii for liberation for control of the oriental fruit fly.

C. History and Evolution of This Work

Exploration for oriental fruit-fly parasites was begun by Territorial agencies in 1948. This work was expanded by the Bureau and the group of cooperating agencies in 1949, and further expanded in 1950. These explorations have been remarkably successful. Many parasites are now attacking the oriental fruit fly in the field with great vigor. There is, of course, always the possibility that a new kind will turn up from any given area. However, the most valuable species have probably been received from the areas already explored.

D. Funds - Annual Expenditures

The expenditure in fiscal year 1950 was about $44,900.

E. Examples of Outstanding Accomplishments

Forty kinds of fruit fly parasites found. One million, four hundred thousand fruit fly puparia were collected by entomological explorers of the Department and its cooperators in Australia, New Guinea, New Caledonia, Africa, India, China, Formosa and the Philippines. These were reared under strict quarantine and produced nearly 75,000 adult parasites of at least 40 different kinds.

Special techniques required already developed. Special culture techniques, developed for flies and their parasites, have been developed and have greatly increased the efficiency of breeding operations.

Three introduced parasites already widespread. The establishment of three of the introduced species has been shown to be island-wide, and in many cases parasitism has very greatly reduced fruit fly infestation in Hawaii.

Biological studies of parasites yield valuable information. The enlargement of our knowledge of the biology and habits of these beneficial insects has been material and will contribute to progress in insect control in many branches of agriculture.

F. Some Additional Work Needed

Additional biological studies of parasites desirable. Substantial progress made in this work project has greatly reduced the anticipated time of its operation. It is now considered possible that exploration will be completed, except for small-scale mopping up operations, in 1951. Extending these operations into 1952 will enable certain biological studies to be brought to completion. Evaluation of the effect of the various introduced parasites on the oriental fruit fly will require continued attention.

Increasing the effectiveness of natural enemies. Methods of increasing the effectiveness of the more important parasites deserve investigation.

CHEMICAL CONTROL OF THE ORIENTAL FRUIT FLY
(BEPQ - No. I-o-3 - Federal-State-Territory - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to provide the orchard grower on the United States mainland with methods of chemical control of the oriental fruit fly, a pest which is extremely destructive in Hawaii, and which might become of great importance on the mainland if it should gain entrance. The current work is particularly concerned with two main objectives: (1) the testing of insecticides as direct fly controls, and (2) the development of lures and repellents. This project is using all of the resources of the insecticide industry allied with entomologists highly trained in the techniques of this field.

B. Currently Active Line Projects

I-o-3-1 - Preliminary laboratory testing of insecticides. To test available chemicals by standard laboratory procedures in order to determine those most toxic to the oriental fruit fly, and to evaluate under laboratory conditions the residual effectiveness of certain insecticides on fruit or foliage taken from field-sprayed trees after known periods of weathering.

I-o-3-2 - Field testing of insecticides. To develop by the use of small or moderate-sized plots effective chemicals, formulations or mixtures to control the oriental fruit fly, by direct contact action, residual action, as systemic poisons or by defruiting or defoliating host plants; to determine the length of residual action and factors affecting it, the effect of the insecticides on plants, their effects on fruit quality, on other pests encountered in conjunction with the fruit fly; and to determine by chemical analysis the resistance of the spray deposits to weathering, absorption or decomposition.

I-o-3-3 - Determination of poison-spray residues in and on fruit at harvest. To determine at what strength and how close to harvest each insecticide or spray mixture that shows promise can be used on fruits without exceeding the limits of safety to the consumer.

I-o-3-4 - Development of treatments and equipment to disinfect aircraft and ships against fruit flies. To develop treatments to free ships and aircraft from infestation by fruit flies.

I-o-3-5 - Development of strains of fruit flies resistant to insecticides. To determine if flies that survive treatment are inherently more resistant to insecticides than the average population and if this greater tolerance will result in the development of so-called resistant strains after several years' use of insecticides.

I-o-3-6 - Development of fermenting or non-fermenting lures or attractants. To develop chemical attractants or lures for use in traps or poisoned feeding stations as a possible means of direct control, for use with insecticides to enhance their effectiveness, and for use in surveys to find out whether the insect is present in a locality or to delimit infestations that may be found on the mainland.

I-o-3-7 - Development of chemical repellents or barriers. To develop chemical repellents or barriers which may be applied directly to plants or fruit or located in their vicinity to protect them against fruit-fly attack.

C. History and Evolution of This Work

Since early in the century efforts have been made to develop adequate insecticide control measures for various species of fruit flies. For the most part, these efforts have been unsuccessful. The advent of the new organic insecticides has completely changed the picture. Soon after the oriental fruit fly appeared in Hawaii, a number of tests were made with the newer insecticides, with promising results. In the summer of 1949 this work was greatly intensified, and the present project was formally established. Current major emphasis is on (1) the testing of new insecticides, and (2) the development of a successful lure for the female flies that could be used with a poison.

D. Funds-- Annual Expenditures

About $84,900 was expended in fiscal year 1950.

E. Examples of Outstanding Accomplishments

Several insecticides found promising for fruit fly control. Numerous coded and most available experimental insecticides have been tested against the adult oriental fruit fly as residual and contact sprays. Among the most promising were dieldrin, aldrin, DDT, Dilan, parathion and certain related phosphate compounds.

Resistance of fly to DDT found affected by diet. Diet has been found to affect the resistance of the fly to DDT. When a special protein compound is made part of the fruit fly diet, resistance to DDT is increased.

Wettable powders more effective residual sprays than emulsions. At the concentrations required for residual action, all materials tested gave practically 100 percent kill of flies present at time of spraying. In a guava area, where fifty-four plots were laid out by bulldozing trails to make them accessible, EPN, parathion, lindane, dieldrin, aldrin, Dilan and DDT wettable powders were promising at concentrations of 1 to 2 pounds of the poison per acre. These insecticides include several in common commercial use on the mainland, and in the event of an outbreak there, DDT, parathion and EPN could be immediately put to use. Parathion and EPN will be valuable at lower concentrations where little residual action is wanted, such as on ripening fruit that is most attractive to the fly.

Dieldrin and aldrin would be useful in areas of wild, non-edible hosts. Dilan and DDT, because of their long residual effect, would be most useful for treating large areas at long intervals.

Defoliation of wild host plants found important. Guava, the most important local wild host, can be defoliated and set of the current fruit crop prevented by the application of sodium monochloroacetate at not less than 30 pounds per acre. Fruit production can be greatly reduced with lesser amounts. The use of this material would eliminate or reduce the number of flies produced.

Protection of mainland found dependent on disinsecting of ships and aircraft. The disinsecting of aircraft and ships against fruit fly is an essential to the protection of the mainland. Dieldrin, aldrin, chlordane, lindane and Dilan were all found to be more effective than DDT in aerosol fogs (aldrin and dieldrin about 10 times), and where these materials can be used safely a choice of space sprays is available for immediate use.

Automatic aerosol dispenser found more effective for fly control in aircraft than hand dispenser. In flight tests between Guam and Honolulu, the automatic insecticide dispensing system was more effective in aircraft than was the hand dispenser.

Present aerosol formula found inadequate for fly control in aircraft after passengers have entered. The currently used aerosol (G-651) is inadequate for the control of flies that may board planes after the pre-loading treatment of 30 grams per 1,000 cubic feet, since passengers cannot be subjected to more than 7.5 grams per 1,000 cubic feet.

Oriental fruit fly found more resistant than melon fly to DDT. In aerosol tests, the oriental fruit fly was more resistant to DDT than was the melon fly. Free-flying flies could tolerate more than caged flies, and flies 8 to 24 days of age were more resistant than younger or older flies.

Powerful new lure found for male fruit flies. A male lure, remarkable for its attractiveness and potency, has been discovered. Methyl eugenol will attract flies ½ mile or more against the wind and will reveal the presence of males in a matter of hours in areas free of the fruits on which the flies breed, if weather conditions permit activity. In 7 months, more than 2 million male flies have been captured in 30 glass traps and in 5 months nearly 1 million in 45 box traps painted or sprayed inside with a methyl eugenol-parathion mixture and located on the rims of gulches surrounding a 125-acre pineapple field. These findings give a preliminary basis for an entirely new method of control. This method would differ from all other chemical methods in that it would be entirely innocuous to beneficial insects.

New techniques and apparatus developed. An insect olfactometer--a device for determining the reaction of various chemicals for insects--has been made that has greatly facilitated the testing of chemical compounds for lures for the female fly. This and other devices developed in Hawaii will materially benefit the whole field of insecticidal control of insects.

F. Some Additional Work Needed

Present line projects, which were established in 1949, cover the entire field as now visualized. In the immediate future, special emphasis should be placed on the following:

Laboratory testing of insecticides against the oriental fruit fly is a continuing process. New compounds must be tested as they become available.

Better lures to trap fruit flies needed. The work on lures is still in the preliminary stages and considerable attention will be given to it. A lure that would strongly attract female fruit flies is much needed.

AREA CONTROL OF THE ORIENTAL FRUIT FLY
(BEPQ - No. I-o-4 - Federal-State-Territory - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this work is to develop methods and techniques that can be used in the event an incipient infestation of Dacus dorsalis, the oriental fruit fly, is found on the United States mainland. This fly, which is a most serious agricultural insect pest wherever it occurs, is not now known to occur in the United States, but may be carried in by commerce. This project is essentially a short-term, emergency one. For this reason, many short-cuts have been made and decisions reached on relatively large-scale operations which would, under normal practices, have been delayed until more detailed results could be obtained from the chemical-control project. The current procedure has been to seek various categories of infested areas and to attempt to control the fruit fly with the best-known combinations of insecticides available. At the same time, basic data are being obtained leading to a large-scale operation which would serve as an example of the operations that would be required to control or eradicate the pest should it become established on the mainland. Learning how to effectively control an insect as versatile as the oriental fruit fly, when large areas rather than single orchards are to be considered, is a difficult and costly process, but its accomplishment will establish a firm line of defense for the farmers of the United States.

B. Currently Active Line Projects

I-o-4-1 - Insecticidal control. To determine the relative effectiveness of different insecticidal sprays, dusts and lures for controlling the oriental fruit fly on an area basis.

I-o-4-2 - Cultural control. To study the effectiveness of different herbicides and defruiting hormones, and to develop crop sanitation and quarantine procedures for reducing oriental fruit fly populations over large areas not necessarily subject to insecticidal control.

I-o-4-3 - Evaluation and improvement of equipment for large-scale application of insecticides. To study the effectiveness of different types of ground and air equipment suitable for use in area-control operations on such specialized environments as residential localities, farmland, and native breeding areas.

I-o-4-4 - Surveys. To develop procedures for conducting surveys to delimit infestations, determine degrees of infestation, study seasonal fluctuations of populations, and to note fly movements with regard to possibilities of reinfestation of the treated areas.

I-o-4-5 - Relationship of large-scale use of insecticides to biological control. To study the relationship between insecticidal and biological control during large-scale area-control operations.

I-o-4-6 - Apparatus and technique. To develop apparatus and techniques for facilitating the various tests undertaken in laboratory and field area-control studies.

I-o-4-7 - Studies on Lanai. To determine the effectiveness and practicability of large-scale area-control operations on a comparatively small, isolated area (island of Lanai) where danger of reinfestation following treatment is minimized and to carry on related studies that may assist in developing area-control procedures against the oriental fruit fly.

C. History and Evolution of This Work

Plans were formulated beginning in 1948 but this work was started in the summer of 1949. The oriental fruit fly is a new pest and its reaction to its environment and its susceptibility to control measures of all kinds must be studied and evaluated. This project uses the current data of all of the other fruit fly projects and applies them, incomplete as they may be, to large-scale operations.

D. Funds-- Annual Expenditures

$77,100 was expended in fiscal year 1950.

E. Examples of Outstanding Accomplishments

Airplane dispersed insecticides found to reduce fly populations greatly. Insecticide tests on the deep, guava-infested gulches using the airplane to apply the insecticide has resulted in great reductions in both adult and larval populations.

Dilute insecticide sprays found effective for oriental fruit fly control in urban areas. A very effective treatment was obtained when DDT was applied as a dilute spray to urban areas filled with host fruits. Results showed a 98% reduction. It is believed that these dilute sprays together with other control measures, such as sanitation procedures, when properly applied might be expected to eradicate fruit fly populations in localized areas.

Fog-sprays found promising. Fog-spray treatments have given very promising results in view of the rapidity and frequency with which large areas could be covered by this method.

Wild fruit host defoliation holds promise in area control of oriental fruit fly. The defoliation of wild host fruits has resulted in practically complete elimination of the guava crop--a method analagous to the fruit-removing techniques that could be applied in mainland orchards.

F. Some Additional Work Needed

Equipment and formulations needed. Information is required on the best types of equipment and formulations for use in controlling fruit flies in large areas of rugged terrain.

Control of wild host trees. A careful appraisal of chemical defoliation of wild host trees is needed before the method is used extensively.

Large-scale area control indispensable. An isolated, infested area should be studied as a basis for attempting a large-scale, high-degree control program in which all of the known control methods developed would be applied against the fruit fly. The results of such a study could be applied on the United States mainland, should eradication of an incipient infestation become necessary.

DESTRUCTION OF THE ORIENTAL FRUIT FLY BY COMMODITY TREATMENTS
(BEPQ - No. I-o-5 - Federal-State-Territory - Regular Funds)

A. Purpose and Nature of Current Work

The purpose of this project is to establish commodity treatments that will eliminate infestation of the oriental fruit fly in fruits and vegetables and permit the farmer to export them if economically feasible. The Hawaiian farmer is sorely beset with quarantines against the export of his commodities because of the fruit fly. These quarantines have severely limited the small farmer and in many instances have served as a complete barrier against the most effective use of small farm holdings. The protection of the United States mainland against the introduction of the oriental fruit fly without undue interference with commerce is the primary purpose of commodity treatments. The current work is devoted to (1) improving all of the known methods of commodity treatments, (2) to greatly increase the number of materials that can be used for this purpose, and (3) to test previously untried methods. This work is of greatest importance to mainland fruit areas by providing procedures by which fruit and vegetables might be made safe to ship out of such areas should they become infested by the oriental fruit fly.

B. Currently Active Line Projects

I-o-5-1 - Development of mortality-time-temperature curves under vapor-heat sterilization. To establish specifications for treatment by vapor-heat of local products to guarantee them safe for shipment to mainland markets without danger of introducing the oriental fruit fly.

I-o-5-2 - Development of mortality-time-temperature curves under low temperatures. To develop low temperature specifications to permit movement of fruits and vegetables from the Hawaiian Islands to mainland markets without danger of introducing fruit flies.

I-o-5-3 - Development of time-dosage-mortality curves under methyl bromide fumigation. To establish specifications for the fumigation of local products to guarantee them safe for shipment to mainland markets without danger of introducing the oriental fruit fly.

I-o-5-4 - New and previously untried fumigants tested for use in commodity treatments. To test new materials for possible value as fumigants for commodity treatment to kill oriental fruit fly larvae.

I-o-5-5 - Dips for commodity treatments. To investigate the possibilities in the use of dips for treatment of flowers and ornamental plants to destroy immature stages of the oriental fruit fly and permit shipment without danger to mainland markets.

I-o-5-6 - Application of radiation to commodity treatments. To investigate the application of various methods of radiation as a means for destroying fruit fly infestation in products.

I-o-5-7 - Infestation indices in commercial grade fruits and vegetables. To determine the degree of fruit fly infestation in commercial grade fruits and vegetables in order to obtain an accurate estimate of the hazard involved of spreading the oriental fruit fly in these commodities. Infestation indices obtained can be used for calculating the extent of treatment required to guarantee movement of commodities to mainland markets without danger of introducing the pest.

C. History and Evolution of This Work

Commodity treatments have been studied in Hawaii for many years, since quarantines on account of both the Mediterranean fruit fly and the melon fly have been in force since 1912. The fruit fly laboratory established in Honolulu in 1930 had commodity treatments as one of its major projects and much basic work was done at that time. When the oriental fruit fly came in, the situation became much more serious because of the many fruits and vegetables attacked by it. Actually treatments necessary to insure freedom from the oriental fruit fly are usually more severe than those required for the other fruit flies, so that establishing safety levels of treatment for it insured freedom from the others. This phase of the work was intensified during the summer of 1949. The immediate need is to relieve the local situation, but the data are all basic to the fundamental problem of shipment of infested commodities and the proper administration of quarantines throughout the United States.

D. Funds-- Annual Expenditures

The expenditure in fiscal year 1950 was about $77,900.

E. Examples of Outstanding Accomplishments

Many local commodities can now be shipped. Papayas, zuccini squash, bell pepper and tomatoes, formerly prohibited, can all be exported following the application of the vapor-heat treatment as worked out under this project.

Vapor-heat treatment modified. This modification has served to reduce the time involved and yet retain the safety factor. It has been learned that the long period of heating the commodity up to the maximum temperature required can be greatly reduced and this modification has been approved for papayas. Other commodities must first be tested for tolerance to the new method before general recommendations can be made.

Pineapple shipments already resumed. Following fumigation with methyl bromide gas, it is now possible for fresh pineapples to be shipped to the United States mainland and markets lost to foreign products can now be restored. These findings are of particular value to the small grower whose production is limited to fresh fruit.

New fumigants found effective against oriental fruit fly. Over fifty new fumigants have been tested to determine their effectiveness against this pest. Three materials, ethylene dibromide, ethylene dichloride, and ethylene chlorobromide, seem most promising, and the results to date are encouraging.

F. Some Additional Work Needed

The line projects set up to cover the expanded program that started during the summer of 1949 cover the needed activities in this field. However, the work along the lines indicated below should be intensified as much as possible:

Emergency commodity treatments. Many times treatments are established on an emergency basis. They are usually very severe. These should be refined. In many cases suitable research can result in modification of the treatment when refinements are carefully studied in relationship to the natural infestation of fruit fly found in the commodity.

New fumigants desired. Screening tests have revealed a number of new fumigant possibilities which should be thoroughly explored. Initial tests are made primarily from the standpoint of insect mortality. The tolerance of commodities varies so greatly that determining the safety of a given treatment on the basis of a few local fruits might limit unnecessarily its value for use on other fruits on the mainland.

PHYSIOLOGY OF THE ORIENTAL FRUIT FLY
(BEPQ - No. I-o-6 - Federal-State-Territory - Regular Funds.)

A. Purpose and Nature of Current Work

The purpose of this work is to obtain basic information on the physiology of the oriental fruit fly, which threatens agriculture in the Hawaiian Islands and in the United States. This project deals with the problems of growth, nervous system, sense organs including the mechanical and chemical senses, behavior, respiration, digestion and nutrition, excretion, metabolism, and reproductive system. This fundamental information is needed as a sound basis for developing various control measures.

B. Currently Active Line Projects

None.

C. History and Evolution of This Work

Physiology as a separate division of entomological science is relatively new and trained workers are very scarce. This project was activated in the closing month of the fiscal year 1950 and is now being developed to permit the setting up of suitable line projects. It has already been demonstrated in other work projects that the behavior of an insect may be a major factor in the success or failure of many control measures. By taking a fundamental approach it is hoped to clarify many of the questions about the oriental fruit fly that have already arisen. Data, methods, and techniques developed will undoubtedly be of tremendous value in solving similar problems for other insects.

D. Funds - Annual Expenditures

About $5,700 was expended in fiscal year 1950.

E. Examples of Outstanding Accomplishments

None.

F. Some Additional Research Needed

The entire subject is a new one, since no fruit fly has ever been the subject of study by trained physiologists. Future needs will be discovered as work progresses.

IMPORTATION OF NATURAL ENEMIES OF FRUIT FLIES
(BEPQ - No. RM-b-264 Federal-State-Industry RMA and Special Funds)

A. Purpose and Nature of Current Work

To search in foreign countries for effective natural enemies of fruit flies and import them into Hawaii for control of the oriental and Mediterranean fruit flies and the melon fly. Such control will not only permit economical production of fruits and vegetables in Hawaii but will be a measure of protection against entry of these pests into the continental United States. This project is in cooperation with state and private organizations. Currently, the work consists of a search through North India, East, South and West Africa, the Philippine Islands and Thailand for effective fruit fly parasites, and their shipment in the living condition to Hawaii for the control of fruit flies.

Certain other parasite expeditions, and the reception and handling of the parasites in Hawaii, are carried on with regular funds. (See statement on BEPQ No. I-o-2, Biological Control of the Oriental Fruit Fly.) Parasite exploration in certain other countries is also being carried on by cooperating agencies.

B. Currently Active Line Projects

(Not subdivided into line projects)

C. History and Evolution of This Work

Biological control work on the Mediterranean fruit fly and the melon fly was first undertaken by Hawaii in 1913 when a number of species of parasites were imported from Australia, Africa and India. Three species were established upon the Mediterranean fruit fly and became abundant, effecting an appreciable degree of control in shallow-pulped fruits such as coffee. One species was established upon the melon fly but without appreciably reducing its destructiveness. In 1935-36 Department entomologists undertook a further importation program from Malaya, India, East and West Africa and Brazil, under an allotment from the Sugar Processing Tax Fund, but this activity was discontinued after a few months and no parasite species were established. The discovery in Hawaii in 1945 of the oriental fruit fly, a much more destructive species, necessitated a renewal of the program, as most parasite species attacking fruit flies prey only upon closely related species and those already present in Hawaii did not attack the oriental fruit fly. The latter especially presents a serious threat to the continental United States, because of possible entry on aircraft. A reduction in the infestations in Hawaii, through natural enemies, will provide some degree of protection.

D. Funds-- Annual Expenditures

Expenditures in fiscal year 1936 under the Sugar Processing Tax Fund amounted to $50,000 and the current work, beginning with fiscal year 1949, involves expenditures of RMA funds totaling about $50,000 per year.

E. Examples of Outstanding Accomplishments

Large quantities of fruit fly puparia, containing at least 20 parasite species, were imported from India, Africa and the Philippine Islands during 1949-50 but the outcome, in terms of establishment and control of the pest, will not be known for several years.

F. Some Additional Work Needed

None other than completion of current work.

CITRUS CANKER SURVEY

(BEPQ - Federal-State - Incipient and Emergency Outbreak Funds)

A. Purpose and Nature of Current Work

This cooperative work program aims to detect infections of citrus canker that may persist in Texas and Louisiana where this introduced disease was previously known to occur. Currently, the work involves intensive inspections of areas where there is a likelihood that infections may persist. Attention is especially directed to host trees that occur in uncultivated sections, or abandoned groves, and in dooryard or ornamental plantings. The work is carried on during periods of the year when infections can be most easily observed.

B. Currently Active Line Projects

Does not apply.

C. History and Evolution of This Work

Citrus canker, a highly infective, destructive disease of citrus, native to the Orient, was accidentally introduced into Texas on nursery stock from Japan about 1911. It spread rapidly and became established in parts of 79 counties in Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas, being discovered at Monticello, Florida, in September 1912. The destructiveness of the disease was well established and the threat to the very existence of the citrus culture in the Gulf States was quickly recognized. The only method of combating the disease was detection and prompt destruction by burning of infected trees, including disinfection of tools and other articles that may have become contaminated. In 1915 the Department and affected States inaugurated an intensive cooperative program to eradicate the disease. This was carried on under police power of the States and included private cooperation involving destruction, without compensation, of all infected or directly exposed trees. Approximately 20 million citrus nursery and orchard trees were destroyed in the course of the eradication campaign. The direct losses to growers were heavy. The cooperative effort resulted in the eradication of the disease from all commercial citrus producing and nursery areas and later from all other areas as far as now known. No infection has been found in South Carolina since 1916, in Georgia since 1917, in Mississippi since 1922, and in Alabama and Florida since 1927. It is believed the disease has been eradicated from these States. The last infection found in Louisiana was in 1940, and in Texas in 1943. It is believed the disease has also been eradicated from these States. Experience has demonstrated, however, that infections can persist in a more or less dormant state for a number of years. There is a possibility that incipient infections may persist in noncommercial sections, especially where host trees occur in uncultivated areas, in dooryards, or in hedge rows. Since 1948, a joint Federal-State survey program has been under way in such situations in Texas and Louisiana, in locations where infection was previously known to occur. Intensive inspections will be necessary to ensure that the disease has been eradicated. To date no infections have been found.

D. Funds - Annual Expenditures

From 1915 to 1935, Federal and State expenditures amounted to nearly 5 million dollars. The effort to eradicate the disease was augmented by allotments from appropriations for relief work ranging from $128,700 in 1936 to $24,700 in 1942, and averaging $89,400 per year. These WPA funds made possible the removal and destruction of many abandoned groves, escaped citrus trees, and hedge rows in Texas and Louisiana where the disease might persist and contributed to the eradication effort. From 1935 to 1944 annual expenditures averaged $12,800 Federal and $13,800 State funds. Expenditures for surveys in the fiscal year 1948 were $18,000 Federal and $20,000 State funds; in 1949 $18,000 Federal and $20,000 State funds; and in 1950, $12,000 Federal and $3,900 State funds.

E. Examples of Outstanding Accomplishments

The protection of citrus culture from a destructive introduced disease through the eradication of citrus canker from the United States will be an unparalleled accomplishment. The benefits to date have permitted the growth and development of an industry of immense importance to agriculture and the consuming public. Had the disease persisted, citrus culture in Florida, Texas, and the Gulf States would have been under a handicap that would have affected the economy of the area and country and would have endangered citrus culture in California and other western States.

F. Some Additional Work Needed

If no infection is detected, the surveys now under way should be continued at least one more year in Texas and two years in Louisiana. It should then be safe to conclude on a sound biological basis that no vestige of the disease remains and that this introduced destructive plant pest has been eradicated from the United States.

AVOCADO, FIG, MANGO, AND MISCELLANEOUS SUBTROPICAL FRUIT PRODUCTION, DISEASES, AND IMPROVEMENT
(BPISAE - b-2-2 - Federal - Regular Funds)

A. Purpose and Nature of Current Work

The objectives of the research on the major subtropical fruits are their commercial improvement and increased production by means of (1) developing new and improved varieties, (2) increasing blossoming and fruit set by plant hormones and cultural practices, (3) selection of better rootstocks, and (4) the control of their various diseases. Most important, insofar as commercial culture is concerned, are the avocado, fig, mango, and papaya, and these are receiving major attention. A number of others appear to have distinct commercial possibilities in the United States proper, including the lychee, pineapple, and jaboticaba, but within the limitations of funds and personnel these minor fruits receive little attention, directed chiefly toward determining their adaptability for different sections and soil conditions.

B. Currently Active Line Projects

b-2-2-1 - Fruit yields and quality of avocados, papayas, and mangoes. Experiments are conducted on breeding and selection of improved varieties, rootstock trials (for avocados), flower bud formation, and the relation of plant hormones to fruit set and maturity.

b-2-2-2 - Avocado, papaya, and mango diseases - to determine their cause and the factors governing infection and spread, and to devise and improve control measures. The primary diseases studied under this project are scab, black-spot, and root-rot of avocado; anthracnose of mango; and leaf and fruit spots of papaya.

C. History and Evolution of This Work

Only sporadic work without formal project outline was done on these subtropical fruits between 1900 and 1935. The early work was largely restricted to the introduction and testing of new varieties. Pineapple growing, a thriving industry in Florida early in this century, disappeared due to disease and to competition with Cuban and Puerto Rican production. The avocado industry in Florida, however, has grown steadily and now approximates 10,000 acres. With this expansion has come a serious increase in orchard and fruit diseases, changes in the market requirements for varieties of certain size, shape, quality, and season of maturity, and the appreciation that much can be done to improve production through proper cultural practices and rootstock selection. The culture of mangoes and papayas is restricted by climatic conditions chiefly to southern Florida. With both fruits the principal need is the development of improved varieties. The earlier work on introduction of the Blastophaga fly for pollination of Smyrna-type figs was basic to the establishment of that industry in California.

D. Funds--Annual Expenditures

Expenditures prior to 1935 varied from $1,000 to $5,000 annually.

Since that date allotments have ranged from $12,000 to $29,670 in 1947, to $16,230 in 1950.

E. Examples of Outstanding Accomplishments

Breeding of improved papaya varieties. A number of improved papaya varieties have been introduced and are widely used. Through years of crossing, strains of uniform fruits of medium size, and high quality suitable for commercial production have been developed. Some of the better known USDA varieties are Fairchild, Orlando, and Kissimmee.

Control measures developed for avocado scab and mango anthracnose. Studies of the nature and methods of infection of these disease organisms led to the development of spray schedules using copper sprays for control. An important aspect of the work was the timing, with respect to blossoming and stage of fruit development, of the several applications necessary for practical control.

Pollination requirements for avocados. The Florida varieties of avocados have been classified as to their pollination requirements. Varieties are either of the A or B type, depending upon the time of day of flower opening and development of the sexual organs. A and B varieties should be interplanted for best fruit setting results. Thus the study of this unusual flower behavior in avocados and the classification of varieties as to type is of great commercial importance.

Fig pollination. The introduction and establishment of the Blastophaga fly, essential for the pollination of Smyrna type figs, resulted in the development of that industry in California. Prior to that work, the Smyrna type figs, now the most important in the State were almost totally unproductive.

F. Some Additional Work Needed

More work needs to be done on breeding and selection of improved varieties of all of the subtropical fruits. Research on subtropical fruits, other than citrus, dates, figs, and avocados, has been sorely neglected by research agencies in general. This is due to the pressure for solution of problems of more economically important crops. Fundamental studies on their flowering and fruiting behavior and their response to varied cultural conditions would greatly further the production of these fruits.

DATE PRODUCTION, DISEASES, AND IMPROVEMENT
(BPISAE - b-2-3 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To develop and test principles, practices, and varieties with a view to promoting the sound development of the date industry. Most of the research is concerned with production problems such as pruning and thinning methods, fertilization, irrigation, and soil management practices, pollination problems, and the testing of new varieties for commercial promise. Much of this is done cooperatively with growers in commercial orchards. Because of the nature of tree crops, this type of research must be continued for many years so that the effects of changing seasonal factors may be adequately assayed. A major phase of the current work is directed toward discovering the causes of several common unsightly fruit blemishes and devising methods for improving the eye appeal of date fruits. Because date culture requires an unusual amount of hand labor, it is necessary for the American date industry to produce a high quality fruit with sufficient added appeal to sell at a premium over the cheaper imported dates that have returned to the market since the close of World War II.

B. Currently Active Line Projects

b-2-3-1 - The relation of mineral nutrients and soil moisture supply to improvement in yield and quality of date fruit. To determine the most desirable fertilizer and irrigation practices to produce the highest yields of the premium quality dates.

b-2-3-2 - Relation of leaf area and amount of fruit per bunch to yield and quality of date fruit. To evaluate the effect of severity of leaf pruning and amount of bunch thinning on total yield, and the proportion of premium quality fruits produced.

b-2-3-3 - Cover crops and soil management practices for improvement of date growing. Chemical studies have been undertaken with soils from date orchards to evaluate the long-term effects and ultimate value of certain soil management practices such as turning in chopped-up prunings, and heavy applications of organic matter.

b-2-3-4 - Pollination studies - to improve size, quality, and yield of date fruit. These studies are designed to evaluate the effect of various methods of handling and storing date pollen, methods of application, sources, and seasonal factors on the set (percentage of flowers developing into fruit), and the quality of fruit produced. Pollen produced by male palms is applied by hand to the flowers of female palms in commercial date culture.

b-2-3-5 - Adaptability and value of certain date varieties for commercial crop production. Some promising new imported varieties are being tested on a semi-commercial scale with cooperating growers in strategically located areas representative of a wide range of soil and climatic conditions.

C. History and Evolution of This Work

Around 1900 the United States Department of Agriculture made several importations of date "offshoots," or suckers, of the important commercial date varieties from the Mediterranean and Persian Gulf regions. Experimental plantings were established in California and Arizona in cooperation with the agricultural experiment stations of those States. In 1907 land was donated to the USDA near Indio, Calif., for the purpose of establishing experimental plantings of dates. At this location the USDA still supports a field station devoted largely to the study of date production problems. In the early years, the principal emphasis of the work was testing the many imported varieties for adaptability to the climatic and soil conditions in the desert area of the Southwest known as the Lower Colorado Basin. As appreciable acreage of the varieties came into commercial production, emphasis was shifted to production problems.

D. Funds--Annual Expenditures

Funds spent on date research have grown from an initial appropriation of an estimated $10,000 per year in 1907 or 1908 to between $20,000 and $30,000 per annum by 1925, and have remained essentially at this same level for the past 25 years. The 1950 allotment was $33,140.

E. Examples of Outstanding Accomplishments

Introduction of superior Mediterranean and Persian Gulf commercial date varieties into the United States and the development of the American date industry to its present position is in very large measure a direct result of the activities of the USDA. A vast number of imported varieties from the old world were tested but only about 10 proved to be of commercial value in the Southwest. These are the basis of the industry today.

Pollination studies with dates have demonstrated that pollen from certain male varieties tends to induce early ripening, and otherwise influences fruit development. Growers make practical use of this knowledge in districts where dates tend to ripen later than desirable by using pollen from male varieties that induce early ripening. In addition, a method has been developed for preventing the sometimes disastrous effect of cold weather on fruit set. In the past, cold weather occurring in the early part of the pollination season some years caused serious reduction in yield because of poor set.

Leaf pruning and bunch thinning experiments conducted over many years with most of the important commercial date varieties showed the important relationship of these practices to the maintenance of high yields of premium quality fruit. The pruning and thinning methods now recommended are based on these studies, and are widely used by commercial date growers.

Irrigation studies with dates indicated to growers that many of the areas of low-vigor palms in their orchards were caused by poor water penetration and hence inadequate moisture supply. These studies emphasized the importance of adequate soil moisture throughout the season, but especially in the period of rapid fruit development, for producing heavy yields of high-quality fruit. These studies have formed the basis for improved irrigation methods by growers, and consequent increased returns.

Technical studies. Not all of the studies undertaken with dates or other crops have had immediate, practical application in solving cultural problems. Often the objective of some studies is simply to learn as much as possible about the structure and growth processes of the plant in question, and the factors that influence them. The background of technical knowledge gradually acquired from such studies frequently provides tools or channels for reasoning which help in the solution of practical problems. For example, laboratory studies on factors affecting date pollen germination in test tubes showed that it germinated very slowly, if at all, at temperatures below 60°F. This furnished the key which made possible the isolation of the cause of poor fruit set under orchard conditions, and suggested a control measure that subsequently proved to be the practical solution of the problem.

F. Some Additional Work Needed

Because funds available for date research have remained relatively static for the past 25 years, the tempo of work has slowed down appreciably during the last decade because of the sharp increase in the costs of supplies and services. During this 25-year period the date industry established by the USDA has grown from less than 1 million pounds annual production to more than 30 million pounds in 1950. The recent completion of the Coachella Branch of the All American Canal is now opening new lands suitable for date culture. This region now produces about 80 percent of the dates grown in the United States, using water from deep wells. Many new problems arise, such as work on certain palm and fruit diseases, and acceleration of work on studies leading to better cultural practices for production of premium quality fruit, and cultural studies with such new and promising varieties as Medjhool.

In February 1947 a brief, outlining in detail the need for expanded date research, was prepared by the Date Institute Committee. This was endorsed by all the leading farm organizations in date-growing areas, and filed with the Secretary of Agriculture, the Agricultural Research Administrator, the Chief of the Bureau of Plant Industry, and the Congressmen and Senators representing date growing regions.

FOOD CROP INVESTIGATIONS
(OES - No. b-1-9 - Federal-State - Regular Funds)

A. Purpose and Nature of Current Work

To improve the yield and lower production costs of food crops in Puerto Rico and to develop fundamental information on the production of food crops for tropical and subtropical areas. The current work is particularly concerned with tomatoes, sweetpotatoes, corn, mangos, papayas, and other tropical fruits. The work on sweetpotatoes, tomatoes, and papayas is carried on in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering. This work is carried on at the Federal Experiment Station at Mayaguez, Puerto Rico.

B. Currently Active Line Projects

b-1-9-2 - Stabilization and improvement of USDA-34 sweet corn.

To further improve, through breeding and selection, a variety of sweet corn known as USDA-34, which is the most important variety of sweet corn adapted to tropical conditions.

b-1-9-5 - Development and production of tropical fruits.

To improve quality and production of tropical fruits such as mangos, papayas, avocados, and mangosteens.

b-1-9-6 - The improvement of tomato varieties for warm climates.

To introduce genes for disease resistance, production, and heat tolerance into tomato varieties adapted to warm climates.

b-1-9-7 - Papaya improvement. To develop papaya varieties resistant to known common virus diseases, and possessing superior characteristics of fruit shape, setting, flavor, and firmness.

b-1-9-8 - Sweetpotato improvement. To improve quality, production, and disease resistance in sweetpotatoes by hybridizing Jersey and moist flesh varieties. Seeds resulting from such crosses will be made available to the National Sweetpotato Program for further testing and selection.

C. History and Evaluation of This Work

The basic legislation establishing a Federal Experiment Station in Puerto Rico in 1901, stipulated that programs should be initiated to improve food production. The lack of extensive and fundamental information on the growing of food crops in the Tropics can be considered appalling, in view of the many millions of people living in tropical areas. In many tropical countries a high percentage of the food consumed is imported in the form of cheap foods, in exchange for tropical products. During World War II, one of the big problems in feeding our troops in tropical areas was the lack of information on growing foodstuffs in the Tropics. The program at the Federal Experiment Station has been pointed in part towards meeting these needs. Sweet corn varieties commonly grown in the continental United States have often been tried in the Tropics, but they are not adapted to tropical conditions. Shorter day lengths of the Tropics, compared with those of the Temperate Zone, during the growing season, do not permit normal development of the continental varieties. These varieties are also susceptible to diseases, particularly leaf stripe and yellow stripe mosaic. With the establishment of a Land Grant College Experiment Station in Puerto Rico in 1934, the work with food crops for Puerto Rico has become largely the responsibility of the Experiment Station of the University of Puerto Rico. The Federal Experiment Station has continued some fundamental investigations on papayas and tomatoes, particularly in the field of plant breeding, in cooperation with the insular station and the Bureau of Plant Industry, Soils, and Agricultural Engineering. In recent years an important phase of the program has been the breeding of crops which will flower and seed in Puerto Rico because of environmental conditions. An example of such work is the breeding of sweetpotatoes to improve varieties now grown in the continental United States. Development of such fundamental information and the actual production of new varieties adapted to tropical conditions has resulted in greater food production in the Tropics.

D. Funds--Annual Expenditures

The average expenditures for this work during the years 1935 to 1944 amounted to about $15,000 per year. Figures on expenditures previous to this date are not available, but it is estimated that they did not exceed $8,000 to $10,000 per year from 1901 to 1935. Expenditures from 1945 to 1949 ranged from $15,000 to $22,000. In 1950 the expenditures amounted to $22,600.

E. Examples of Outstanding Accomplishments

The development of a tropical sweet corn - USDA-34. In 1934, as a culmination of 16 years of breeding and selection work, the Federal Experiment Station in Puerto Rico made available to the farmers of Puerto Rico and other tropical countries USDA-34 sweet corn. This variety still remains the outstanding sweet corn variety for the Tropics; since its development it has been distributed throughout the tropical world.

Improved tomato hybrids. Forty-three selections from hybrids between native and imported tomato varieties produced an average of over 2-1/2 times as much marketable fruit as did standard varieties. The local or native tomatoes are highly resistant to many of the more common tomato diseases, such as fusarium and blight.

Bunchy-top resistant papaya. Forty-four different varieties of papaya from widely separated locations in the tropical world have been introduced for testing against the destructive bunchy-top virus, which has made papaya production virtually impossible in many areas. Valuable genes for fruit size, shape, quality, growth habits, and setting characteristics have been discovered in these stocks. No true papayas have been found to be completely resistant to bunchy-top, but some papaya relatives show considerable resistance.

Extensive vegetable adaptation trials were conducted. Forty-five common vegetables and several varieties of each were grown at sea leavel, 2,000 feet, and 3,000 feet, in Puerto Rico to determine those best adapted to the different conditions of temperature and rainfall in summer and winter. A list of vegetable varieties can now be recommended for different seasons at different altitudes in Puerto Rico. This is one of the results of an extensive study on the production of vegetables in the Tropics. A bulletin has been prepared which gives recommended varieties, cultural practices, and control of insects and diseases.

Jersey-type sweetpotatoes flower in Puerto Rico. Sweetpotatoes cultivated in the continental United States for decades without flowering have bloomed and seeded normally in Puerto Rico. In breeding experiments the difficult-to-flower Jersey varieties, Orange Little Stem, Big Stem Jersey, Vineland Bush, and Yellow Jersey have been induced to flower and have set seeds in self-pollinations and in crosses with other varieties. The Jersey-type varieties flower in field plots during the same period as the moist-fleshed varieties (October, November, December, and January) and produce blossoms and seed similar to the latter varieties. The achievement of sexual reproduction in the Jersey varieties will permit a program of hybridization and selection previously impossible, for the interchange of valuable genetic characteristics among the Jersey varieties, themselves, and also with the group of moist-fleshed varieties. A cooperative project has been worked out between the Federal Experiment Station in Puerto Rico, where the flowering was induced, and the Division of Vegetable Crops and Diseases of the Bureau of Plant Industry, Soils, and Agricultural Engineering for the introduction of sexual seeds to the sweetpotato breeders of the continental United States.

F. Some Additional Work Needed

Coffee research. The current scarcity of coffee, and resultant high prices, has made consumers in the United States aware of our dependency upon Latin America for the production of this important commodity. Four-fifths of the world's coffee comes from Central and South America. The world trade and economic life of many Latin American countries is completely dependent upon this crop. During recent years coffee production has declined as a result of poor cultural and agronomic practices and improper land use in all producing areas. It has been the custom to move from one area to another, as soils became exhausted, but eventually as the lands become poorer, production and the life of the trees has been greatly reduced. Higher wages and lower yields have greatly increased production costs. In general, cultivation is still done with the hoe, and the number of hours required to maintain a unit of trees is the same as it was a decade or a century ago. A sound research program designed to improve methods of production is necessary to restore the coffee industry to its former position as a leading tropical crop. The major objectives of this research are: (1) development of cultural practices to insure high production; (2) undertaking fundamental investigations on the problems of flower production and fruit set and retention; (3) improvement of varieties through breeding and selection; (4) identification of insects and diseases attacking coffee, and development of methods for their control.

Increase tropical fruit production. The Federal Experiment Station has perhaps the best collection of Indian mangos in the Caribbean area as well as many other fruits of importance. Most tropical fruits grow wild and are seldom produced commercially. There is little scientific knowledge available for large scale production yet many of these fruits would be valuable additions to the American table because of their food value and delightful taste flavors. Mango trees exactly like the parent tree can not now be grown from seed. It is not known why some very desirable varieties of mangos fail to fruit or if pollination is necessary for fruit production. These are only examples of the problems confronting the establishment of a mango industry. Another highly prized and delectable fruit, the mangosteen, has been grown for years at the Federal Experiment Station but has never become commonly cultivated because of difficulty in growing and transplanting the seedlings. Studies on propagation, including grafting and management of this fruit as a crop should be made.

Research investigations on cacao. There is a need for (1) establishment and maintenance of a cacao breeding garden in Puerto Rico, and (2) the breeding of high-quality, high-yielding, disease-resistant cacao trees for distribution to Latin American countries cooperating in this program because (a) the world production of cacao has declined rapidly in recent years, particularly because of serious disease problems encountered in all the cacao producing areas. Considerable research on cacao is being carried out at the various cooperative experiment stations of the Department in Latin America, and also at the Instituto Inter-Americano de Ciencias Agricolas in Turrialba, Costa Rica. (b) The presence of one or more important diseases in all of these areas is a serious obstacle in carrying on a well rounded program of research. (c) The island of Puerto Rico is free of these diseases. Its location and isolation from centers of infection make it a suitable place for conducting experimental work and for maintaining a quarantine garden of high-yielding strains and other desirable germ plasm. At the present time, the presence of the destructive witch's broom, a virus disease prevalent in most producing areas, prevents the free exchange of plant material which is necessary if cacao production is to be increased in this hemisphere.

LIBRARY
UNIVERSITY OF ILLINOIS

CROSS REFERENCES -- PRODUCTION

For additional information especially pertinent to subjects reported on in this chapter, see also:

BEPQ-C-c-1, Chapter 35, Mexican fruit fly control
BEPQ-I-b-10-Chapter 31, Japanese beetle
BEPQ-I-e-8-Chapter 31, white fringed beetle investigations
BEPQ-I-g-1-Chapter 38, bee diseases and poisoning
BEPQ-I-g-2-Chapter 38, bee management
BEPQ-I-g-3-Chapter 38, insect pollination (bees)
BEPQ-I-k-1-Chapter 31, natural enemies of insect pests and weeds
BEPQ-I-m-3-Chapter 31, insecticide residues
BEPQ-I-n-5-Chapter 31, effect of insecticides on parasites and predators
BEPQ-White fringed beetle control, Chapter 35
BEPQ-Emergency surveys of insect pests injurious to vegetables and fruit crops, and their control requirements, Chapter 14.
BEPQ, BAI, BDI, BPISAE, BAIC-RM:b-72, Chapter 31, toxicological effects of insecticides, fungicides, and herbicides on soils, plants, and animals
BPISAE-b-11-1-Chapter 13, introduction and evaluation of fruit, nut, and vegetable crops
BPISAE-b-12-1-Chapter 31, nematode studies
BPISAE-d-2-1-Chapter 22, fertilizer materials, improvement, etc.
BPISAE-q-2-2-Chapter 38, plant disease survey
BPISAE-RM:b-48-Chapter 31, research on nematodes
BPISAE-RM:b-57-Chapter 31, methods and equipment for weed control
BPISAE-RM:b-68-Chapter 30, equipment and formulations -- insecticides and fungicides
BPISAE-OES-RM:b-111-Chapter 38, introduction and testing of new plants, etc.
BPISAE-RM:b-532-Chapter 38, agricultural chemicals on insect pollination
OES-b-1-11-Chapter 31, control of insect pests and diseases

UTILIZATION INVESTIGATIONS ON FRUITS, VEGETABLES, AND OTHER AGRICULTURAL PRODUCTS OF THE SOUTH

(BAIC - b-1 - Federal-State - Regular Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To develop new and improved processes and products, utilizing southern fruits and vegetables, and byproducts of their production and processing; to conduct fundamental chemical, technological, and microbiological investigations on the composition of these fruits and vegetables and on changes occurring in processing, preservation, and storage of products and byproducts in order to improve the quality and increase the market value of the products, to eliminate or utilize production and processing wastes, and to increase the efficiency and economy of processing operations.

Current work includes the recovery of citrus-juice-flavor essence and adaptatio of this process to industry. Considerable attention is being given to quality control and production of improved single-strength and concentrated citrus juices in Florida and Texas. Determination of the origin and control of pectic enzymes in commercial cucumber brines is under study.

B. Currently Active Line Projects

b-1-1-1 - Production of animal feed from citrus waste and citrus molasses. To investigate the moisture-absorbing properties of dried citrus pulp and molasses, and to determine the optimum molasses content for storage and handling of feed from citrus waste.

b-1-1-2 - Rapid methods of estimating microorganisms in citrus products. To devise rapid methods of estimating microbiological population in citrus products. Possible methods include the use of stains to differentiate tissue from microorganisms, direct count by number, and the use of direct and special microscope lighting with prepared mounts, chemical indicators, and ultraviolet light analyses.

b-1-1-3 - Coliforms in Florida citrus products. To investigate the possible sources of coliform bacteria in citrus juices and concentrates; to make a systematic study to determine their identity, especially those resembling E. coli; and to determine their significance as far as processed-product quality and plant sanitation are concerned.

b-1-1-4 - Effect of micro-organisms on the flavor quality of Florida citrus products. To investigate the changes in quality of concentrated juices produced from Florida citrus fruits due to slime-, gum-, and acid-forming organisms (exclusive of coliforms resembling E. coli) at low temperatures, the source of these organisms, the relation to plant sanitation, and means of avoiding deterioration from this cause.

b-1-1-5 - The preservation of single-strength juices of Texas white grapefruit, oranges, and tangelos. To investigate factors affecting the quality of processed single-strength juices of Texas white grapefruit, oranges, and tangelos. There is cooperation with Texas Agricultural Experiment Station, Texas Citrus Commission, and a large grower.

b-1-1-6 - Frozen-concentrate production from Texas white grapefruit, oranges, and tangelos. To develop new or improved processing methods for utilization by concentration of juices from Texas white grapefruit, oranges, and tangelos. Studies will be made as to the effect of variety, maturity, root stock, and cultural practices on the ultimate quality of concentrates. There is cooperation with Texas Agricultural Experiment Station, Texas Citrus Commission, and a large grower.

b-1-1-7 - Origin of enzymes in commercial cucumber fermentations. To determine the sources of the pectic enzymes in commercial cucumber fermentation that are responsible for spoilage (softening) of cucumber salt-stock. This includes a study of the cucumber fruit itself and the micro-organisms in the brines as contributing factors. There is cooperation with North Carolin Agricultural Experiment Station, under a memorandum of understanding, and with a commercial pickler.

b-1-1-8 - Controlling enzymes in commercial cucumber brines. To develop means of controlling pectic enzyme activity in commercial cucumber brines in order to prevent softening spoilage of salt-stock cucumbers. There is cooperation with North Carolina Agricultural Experiment Station and a commercia pickler.

b-1-1-9 - Characterization and stabilization of the coloring matters in Texas grapefruit. To investigate the properties and reactions of the coloring matter in Texas pink and red grapefruit with the objective of improving color quality in juice and concentrate products. The investigation is being conducted in cooperation with the Texas Citrus Commission and the Texas Agricultural Experiment Station under a memorandum of understanding.

C. History and Evaluation of This Work

In the early 1900's, work of the Bureau contributed to the development of industrial canning, preserving, and dehydration, and established methods for detection and control of spoilage in food and food products. Investigations on various food products were carried on in more recent years by the Bureau of Chemistry and Soils, and all such investigations on fruits and vegetables were assigned to this Bureau April 3, 1935. In subsequent reorganizations leading to the present Bureau of Agricultural and Industrial Chemistry, research on fruits and vegetables under this project was limited to the general territory and products of the southern states, to be conducted at the field laboratories at Raleigh, N. C., Weslaco, Tex., and Winter Haven, Fla. Continuing technical assistance is given to processors, and the Bureau is a source of information of general value to the industry.

D. Funds - Annual Expenditures

With the work on southern fruits and vegetables financed from a fund covering crops of several regions, estimates for early research on southern crops are difficult to obtain.

The Bureau's Winter Haven, Fla., laboratory was established in 1931, with funds provided by local popular subscription, on land later deeded to the Federal Government. The value of land, buildings, and facilities was approximately $25,000. In the fiscal year 1940, $19,000 was appropriated to enlarge the laboratory, providing space for pilot-plant as well as expanded laboratory-scale investigations. During the period 1942-47, the laboratory staff included several research fellows of the Florida Citrus Commission, with whom cooperative investigations were carried out.

Allotments to the Winter Haven laboratory for operating expenses are not available for the fiscal years 1932 through 1935. From 1936 through 1943 they averaged $14,000 annually.

The first appropriation for the laboratory in the Rio Grande citrus-producing area of Texas was made in the fiscal year 1932, the original laboratory, located midway between Weslaco and Mercedes, being built by contributions from the Chambers of Commerce of these two cities. In 1939, $25,000 was appropriated for the construction at Weslaco of a modern research laboratory, including facilities for pilot-plant experimentation.

Allotments to the Weslaco laboratory for operating expenses averaged $10,250 annually from 1932 through 1943. In 1946, a substantial increase in appropriation was made to provide additional personnel and to complete equipment of the laboratory for a broader program of research on all phases of Texas citrus-fruit processing and utilization.

The Bureau's laboratory at Raleigh, N. C., established in 1936, is conducted in cooperation with the North Carolina Agricultural Experiment Station in buildings of North Carolina State College. From 1936 through 1943, allotments to this laboratory for operating expenses averaged $7,500 annually.

Between 1944 and 1946 the total annual expenditures under this project increased from $45,000 to $87,000; the average annual expenditure from 1947 through 1949 approximated $97,000; and in 1950 the expenditure was $94,000.

E. Examples of Outstanding Accomplishments

Cucumber-pickle consumption expanded by improvements in salt-brine fermentations. This fermentation work resulted in a large expansion of the cucumber-pickling industry, particularly in the southeastern states, by adoption of practices that reduced losses and improved the quality and market volume and value of the products. During World War II, application of these brine- and salt-preservation methods to a wide variety of other vegetables was a major contribution to both military and civilian food supply, permitting successful bulk and home preservation of large quantities of vegetables for which canning facilities and materials were not available. Some applications of these methods were adopted by large canners for economical bulk handling of stock for manufacture of soups and similar products.

Studies on the inheritance composition of Washington Navel oranges of various strains, and maturity data on the California-Washington Navel orange were of inestimable value in the initial development of maturity standards for citrus fruits, and did much to place the citrus industry in the United States on a sound profitable marketing basis.

Fundamental research was the basis of the modern citrus-juice canning industry, first regarded as a byproduct outlet for surplus and culls but now grown to a major industrial operation consuming large quantities of selected fruit at profitable prices. Objectionable liquid wastes that burdened the canning and citrus feed plants with the expense of disposal are being more completely utilized by adoption of processes that make use of this material for the production of chemicals and protein feeds.

Method of preparing full-flavored, fruit-juice concentrates. U. S. Patent 2,453,109 (1948). This development, consummated under a cooperative agreement between the Bureau and the Florida Citrus Commission, made possible a new and profitable industry. In Florida alone, the citrus-frozen-concentrate industry has developed in 6 short years (1944-1950) to a volume of 22,000,000 gallons of concentrate, valued at $132,000,000.

All concentrate plants are increasing their production capacity, and during the 1950-51 season the 16 plants in Florida may produce 35,000,000 gallons of orange, grapefruit, tangerine and blended frozen concentrate. Two plants are being erected in Texas, and several are already in operation in California. During the canning season, frozen pineapple-juice and grape-juice concentrates will be commercially packed.

Pasteurization aids pickle industry. Widespread application of a specially adapted pasteurization process has greatly enlarged the market for cucumbers during the past decade by making a new type of pickle available. These are fresh-pack pickles, packed without the usual fermentation or curing in brine. The use of pasteurization has also proved advantageous in preserving the quality of brined-pickle products. That the economic benefits to farmers have been substantial is evidenced by the fact that pasteurized pickles now take about 1½ to 2 million bushels of cucumbers annually. During the past 10 years, the consumption of pickles of all types has almost doubled (from 15 million cases up to 25 million cases). On the assumption that pasteurized pickles constitute 15 percent of the total yearly pack of pickles (all types), they would amount to about 5 million cases, valued at approximately 10 million dollars.

F. Some Additional Work Needed

Develop more extended uses of citrus molasses. Molasses obtained by evaporation of the liquid waste pressed from citrus pulp before drying is in surplus production and finds limited outlets in competition with blackstrap molasses. There is urgent need for fundamental research on the conposition of the molasses. Such information would serve as a basis for developing practical methods of eliminating bitterness and altering flavor in processing, and for devising new and more profitable uses for the product.

To apply the results of fundamental investigations on biochemical causes of softening of cucumber salt-stock to the development of improved methods of cucumber brining for pickle production. Current investigations are providing fundamental information on the enzymic causes of softening and deterioration of cucumber salt-stock, and are developing methods for detecting the enzyme that causes softening. There is urgent need for extending this information and applying it to the development of basically improved methods of cucumber brining. Losses amounting to several million dollars a year result from softening and bloater formation, much of which could be saved by the development of positive control of the brine-fermentation process. To accomplish this result, it will be necessary to know the exact mechanism by which microbiological action and biochemical changes lead to firm, high-quality stock in some cases and to soft, worthless stock in others.

To determine the suitability of sub-tropical fruits for processing. Although dooryard plantings of sub-tropical fruits in Texas have been successful for many years, organized efforts of nurserymen and growers are just making a start toward commercial production, particularly of papayas and avocados. When commercial production is established, there will inevitably be cull fruits and perhaps an initial surplus available for processing. Many persons have already made inquiry regarding possibilities of profitable disposition of such surpluses. If methods for processing can be established prior to the development of such a surplus, it will serve to keep the new industry on a sound economic footing.

To study the suitability of southern tomatoes for canning. Production of tomatoes in the South has always been primarily for the fresh-fruit market, with only surplus and end-of-season crops available for processing. In general, such tomatoes have not been found suitable for yielding fancy packs. This has caused the canned-foods industry to believe that fancy tomatoes cannot be packed in the South, with the consequent development of a price differential and economic loss to the southern farmers and processors.

To determine suitability of southern vegetables for freezing. Broccoli, lima beans, southern peas, and sweet corn have for some time been commercially grown in the South for processors of frozen vegetables. Dissatisfaction has been expressed by the processors with the quality of these packs, especially in the case of lima beans.

UTILIZATION INVESTIGATIONS ON FRUITS, VEGETABLES, AND OTHER AGRICULTURAL PRODUCTS OF THE WEST

(BAIC - b-8 - Federal-State - Regular Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To make chemical and technological studies, especially of local significance, of the composition of fruits and vegetables grown in certain western areas, and determine the best uses of these commodities either as fresh products or as processed foods. Current work is directed toward problems that are especially significant to the area comprising southern California and Arizona (laboratory located at Pasadena, Calif.), and the area comprising Idaho and the central and eastern parts of Washington and Oregon (laboratory located at Pullman, Wash.). Technological studies are made to improve the retention of color, flavor, texture, and nutritive value of processed fruits and vegetables by the development of new and improved methods of preservation. Processing studies are made on the utilization of cull and surplus fruit and vegetable crops in the form of processed food products or byproducts. New and improved methods are also developed for the disposal or utilization of waste materials from local fruit and vegetable processing plants. In carrying out these investigations, close cooperation is maintained with other Federal and State agencies, cooperative grower organizations, and commercial food processing plants.

B. Currently Active Line Projects

b-8-1-5 - Investigations on the modification of juice from central Washington-grown grapes. To develop a process whereby the acidity and ash of juice prepared from central Washington-grown Concord grapes can be standarized at optimum levels for consumption as juice or for further processing.

b-8-2-2 - The canning technology of vegetables grown in Idaho and the areas of Washington and Oregon east of the Cascades. To study the technology and adaptability for canning of vegetables grown in different producing areas of the Pacific Northwest for the purpose of improving the quality and reducing the cost of the commercially canned products.

b-8-2-3 - The freezing technology of vegetables grown in Idaho and the areas of Washington and Oregon east of the Cascades. To study the technology and adaptability for freezing of vegetables grown in different producing areas of the Pacific Northwest for the purpose of improving the quality and reducing the cost of the commercially frozen products.

* Investigations of factors in raw material selection and processing that affect the quality of Western Washington and Oregon apple juice. To determine the effect of maturity, grade, and condition of apples of the Pacific Northwest on their juice quality. Results of these studies will be applied in the production of juices of improved quality.

* Line of work for which no symbol has yet been assigned.

b-8-1-11 - New and improved methods for the processing and preservation of packaged dates. To develop methods for cleaning dates to make them more sanitary and attractive in appearance, and to devise means of pasteurizing dates in hermetically sealed containers to prevent losses caused by spoilage and color changes during storage.

b-8-1-12 - Processing of Southern California and Arizona citrus juices and their preservation by quick-freezing. To develop new and improved methods for the packaging and freezing preservation of citrus products to prevent development of off-flavors, jelling of the product, and other chemical changes that may occur during storage at refrigeration temperatures.

b-8-1-13 - Processing of standarized single-strength canned juices from southern California and Arizona grapefruit. To study the chemical composition of southern California and Arizona grapefruit through several growing seasons, and to devise methods for correcting natural deficiencies in the sugar-acid ratio of the juice to enable processors to put up a uniformly high quality pack during a full canning season.

b-8-1-14 - Freezing preservation of segments and slices from California and Arizona grapefruit and navel oranges. To develop new and improved packaging and processing methods for freezing preservation of citrus segments and slices, and to conduct storage experiments on the frozen products to determine what changes in color, flavor and texture may take place at various refrigeration temperatures.

b-8-1-15 - Isolation, identification and characterization of the peroxidase enzymes in citrus fruits. Work under this project is designed to provide basic information regarding the role played by citrus peroxidases in development of undesirable flavors and odors in fresh, frozen, and canned citrus juices. This information is of importance in the development of commercially practical methods for preventing or limiting this undesirable chemical activity during processing and storage.

b-8-1-16 - Preventing or removing the bitter taste in processed navel orange products. To develop commercially applicable methods for preventing or removing the undesirable bitter taste that develops in navel-orange products after processing and storage. Because of this bitter taste, navel oranges are seldom used at the present time for processing. This represents a loss to growers who have no market for their cull and surplus navel oranges.

b-8-2-12 - Improvements in the quality of canned tomato paste. To study the chemical composition of California-grown tomatoes, and to develop improved processing methods for preparation of canned tomato paste possessing better color, flavor, consistency and nutritive value.

C. History and Evolution of this Work

Work on the chemistry and technology of fruit and vegetable products was initiated by the Bureau in 1911 in Los Angeles at the request of the California citrus growers for the purpose of conducting studies on the utilization of cull and surplus citrus fruits. As a result of this pioneer work, the citrus industry built a number of processing plants in California, and later similar plants were built in Florida and Texas to make citrus products and byproducts from cull and surplus fruit. At the end of World War I, the emphasis of research on western-grown agricultural products was shifted from citrus to dehydrated food products in an effort to improve the quality of such products for consumer use. Later, processing studies were carried out on many fruits and vegetables grown in California, and around 1931 pioneer studies were made on the technology of frozen foods at Seattle, Wash. The work on freezing preservation was of material aid in helping this new food industry to get started. Because of the Bureau's previous experience in dehydration of food products, the entire research program on western-grown fruits and vegetables was again shifted to this field during World War II, and studies were carried out in cooperation with the Army Quartermaster Corps and commercial dehydration plants. Current research work is mainly concerned with the chemistry and technology of citrus products, some similar work being done on tomatoes, dates and avocados. At least five new food processing plants have been established in southern California as a result of this research program, and numerous small plants have been given technical assistance with their processing methods. In 1949 the work on chemistry of western-grown fruits and vegetables was moved from Los Angeles to a new laboratory building at Pasadena, Calif.

To study problems in the processing utilization of fruit and vegetable crops grown in certain areas of the Pacific Northwest, a laboratory was established in cooperation with the State College of Washington at Pullman in 1935. This laboratory has since conducted numerous studies on the more important fruit and vegetable crops, giving particular attention to processing problems peculiar to crops grown in this area. Working in cooperation with State horticultural agencies, studies have been made to determine the varieties of each crop that are most suitable for processing and to develop improved methods for handling these crops prior to processing. Studies have also been made to develop new and improved methods for processing certain crops that are not adapted to conventional processing procedures.

D. Funds-Annual Expenditures

During the period 1914-21 the approximate average annual expenditure was $17,300. From 1922 through 1935 the annual average was about $35,500; from 1936 through 1946 it was about $77,500; and from 1947 through 1949 it was about $62,000. The allotment for 1950 was $65,100. The above estimates cover expenditures made at both the Los Angeles and Pullman laboratories. During the period 1947-48 an annual supplementary fund of $2,500 was provided by the California-Arizona Desert Grapefruit Boards for cooperative studies on the chemistry of grapefruit.

E. Examples of Outstanding Accomplishments.

Development of Northwest apple-juice industry. Among the developments of the apple juice industry toward which the Bureau has made important contributions are the commercial application of enzyme clarification, flash pasteurization, and special use of enameled-tin containers. Some progress toward essence recovery and improvements in preparing juice concentrate were also made, and apple varieties of the Pacific Northwest were characterized and classified to permit blending of varieties for the production of a more palatable juice.

Development of commercially canned freestone peaches in the Northwest. Much of the research necessary in pioneering the recently developed and rapidly expanding freestone-peach canning industry may be credited directly to the Bureau's activities in the Pacific Northwest. Special methods were developed for processing freestone peaches which permit the commercial canning of this delicate and flavorful fruit. Investigations made in cooperation with State horticultural agencies on the suitability for canning of a number of freestone peach varieties and on the relation of harvest maturity, ripening, and storage methods to the quality and yield of the canned product have made possible a continual improvement in quality and a reduction in cost of the commercially processed fruit. As a result of this development, a major portion of the Pacific Northwest's freestone-peach crop is now canned.

The froth-flotation process for cleaning vined green peas was developed by the Bureau to remove foreign materials such as weed seeds, and especially nightshade berries and buds, from vined (mechanically-shelled) green peas for canning and freezing. The value of this new process to the green-pea processing industry amounts to about $1,000,000 annually. This value is achieved through a reduction of labor required to sort vined peas, improvement in quality of the processed product, and in the saving of large tonnages of peas which would otherwise be discarded because of heavy contamination with foreign material. The value of commercially manufactured froth-flotation equipment for cleaning vegetables now exceeds $100,000 annually. The process will have other extensive uses for cleaning vegetables, nuts and fruits.

Development of prune and apricot nectars. Processing outlets for soft fruits of the Pacific Northwest have been expanded through the development of prune and apricot nectars. Prune nectar, a new beverage, may be prepared from off-grade Italian prunes, sugar, and water. Apricot nectar offers the most promise for commercial processing of the Wenatchee Morpark apricot, which is unsuitable for canning or freezing. Prune and apricot nectars have been favorably accepted in small-scale commercial tests.

Improvement in canning quality of irrigation-grown tomatoes. Tomatoes grown in the irrigated areas near Lewiston, Idaho, were commonly considered to be of inferior canning quality. Cooperative studies with the State agricultural experiment station have resulted in the selection of improved varieties and processing methods which permit the production of high-quality canned tomatoes in this area.

Development of the 8-to-1 maturity standard for oranges. In the early days of the citrus industry in California, many growers were attempting to get their fresh fruit on the December holiday market, which necessitated harvesting the fruit before it reached full maturity. This early sour fruit was a disappointment to the consumer, and as a consequence the market was ruined for larger crops of fully matured fruit harvested later in the season. At the request of the citrus industry and State enforcement agencies, studies were made on the composition of mature oranges which indicated that a maturity standard for oranges should contain 8 parts of soluble solids (sugars) to 1 part of acid before the fruit would be considered edible and could be legally picked and shipped. This ratio of soluble solids to acid was adopted by the State as the legal maturity standard for oranges, and later Florida adopted a similar modified maturity standard for its oranges.

The adoption of this maturity standard for oranges was instrumental in raising the quality of oranges offered for sale, and effected a large saving to the consuming public.

Development of the ethylene process for aiding the natural coloration of citrus fruits. Another important problem confronting the California citrus industry was that of trying to furnish the market with mature fruit that was fully colored rather than only partially colored. The use of kerosene stoves in packing houses to keep fruit from freezing during cold spells had indicated that products of combustion from these stoves tended to remove the green color from poorly colored fruit and produce a full color in fruit stacked close to this source of heat. Experimental work carried out on the chemistry of the products of combustion from kerosene stoves, later led to the discovery that ethylene gas stimulated the activity of enzymes responsible for the coloring of citrus fruits. A trace of pure ethylene gas, used under controlled conditions, was shown to be effective in bringing out a full, natural color in oranges, lemons and grapefruit. The method has been in commercial use in California, Arizona, Texas, and Florida since 1924. Citrus fruits having a natural, fully-developed color bring a higher price on the market, so this method has helped citrus growers to realize a greater return on their crops than was previously obtained. The method is simple, cheap to operate, and very effective.

Use of ethylene gas on "sticktight" walnuts. During certain harvesting seasons, the Persian-walnut industry in southern California was troubled with the presence of nuts from which it was difficult to remove the outer shell or husk. Such walnuts were termed "stricktights" by the industry, and inability to market these nuts constituted a financial loss to growers. In conjunction with investigations of the use of ethylene gas for coloring citrus fruits, it was accidentally discovered that when "sticktight" walnuts were exposed to this gas the husks could be easily removed by ordinary methods. Further experimental work in this field proved that the use of ethylene gas for this purpose was practical under commercial conditions. To date, many thousand tons of "sticktight" walnuts have been successfully treated by this method with considerable saving to the growers.

Development of new frozen fruit purees. For many years fruits have been preserved by adding sugar and heating in sealed glass or tin containers, and although such canned fruits retained little fresh flavor, they were widely accepted by the trade. With increased popularity of fruit ices, sherberts, and ice cream, the lack of a fresh-fruit flavor in products made from heat-preserved fruits became more and more apparent. In order to provide preserved-fruit products possessing more natural flavor, methods were devised for pureeing whole fruits such as plums, peaches, apricots, and berries, by passage through a fine screening device, mixing with sugar, and quick-freezing in closed containers. Later it was discovered that citrus fruits, such as oranges and lemons, could be similarly processed without developing off-flavors during storage. Freezing preservation of fruit purees has proved to be a highly efficient and economical method for preparing fruit bases possessing natural fruit flavor, color, texture, and nutritive value. Frozen fruit purees are now being commercially produced in large quantities for use as ice cream and sherbet bases, sundae toppings, pastry and beverage bases, and in the manufacture of jams, jellies, marmalades and fruit ades. Pureeing of fruits for freezing preservation offers a distinct advantage to growers, since sound fruits having good flavor and color can be utilized regardless of shape, size or blemishes that would make them unfit for the fresh-fruit market or commercial canning. Of particular significance to California citrus growers is the possibility that frozen purees can be produced successfully from navel oranges, which have not previously been used for manufactured products because most navel-orange products develop a bitter taste during storage.

Method for canning and pasteurizing soft dates. Under present processing practices, dates are generally put into paper cartons and treated with small quantities of gaseous preservatives. Vapors of these chemicals permeate spaces between the fruit and are alleged to inhibit growth of spoilage micro-organisms. Since this method had not proved to be entirely satisfactory, because dates packaged and treated in this way do not keep well at high humidities and temperatures, a new method of preserving high-moisture dates was developed. The fruit is packed in tin cans, from which the air is exhausted and replaced with nitrogen gas, after which the cans are hermetically sealed. The contents of the can are then pasteurized by heating in boiling water for a short period, followed by air cooling. Dates preserved in this manner have been kept at a temperature of 90°F. for 1 year and longer without evidence of spoilage or color changes. A similar pasteurization method, now in commercial use, was developed for the preservation of low-moisture dates. In this method only the vacuum treatment is used.

Improvement in the quality of unpasteurized, refrigerated orange juice. Unpasteurized, refrigerated orange juice, processed and packaged by improved methods that were developed through Bureau research, is now being shipped commercially from citrus producing areas in California to distant markets, with little loss of flavor or vitamin C content. Research also resulted in the improvement of methods for handling highly perishable orange juice so that it can now be kept for 2 weeks or more at refrigeration temperatures. Even after 3 weeks storage, this product is superior in flavor to many canned orange juices now on the market. Essentially, the method consists of carefully reaming the fruit, removing dissolved oxygen, packaging, and storing at 30°F. Carload lots of unpasteurized orange juice, packed in 1-gallon cans and refrigerated with ice and salt, have been shipped successfully from California to New York City without any losses. Approximately 2-1/2 to 3 million gallons of refrigerated orange juice are shipped annually from Los Angeles to cities within a 500-mile radius.

Freezing preservation of avocado paste. Avocados are highly perishable, and many attempts in past years to preserve them in various forms have been unsuccessful. Freezing of avocado slices has not been satisfactory, since they become mushy and badly discolored on thawing. However a frozen avocado paste, containing small quantities of lemon juice, salt, and onion powder, was recently developed by the Bureau. Packaging may be done in hermetically sealed cans, or preferably in collapsible soft metal tubes. Extensive market surveys have been carried out on consumer acceptability of this new product, and plans have been made by some packers to start commercial production.

Improved navel-orange products. Navel oranges are processed only in limited quantities, because during many seasons the juice turns bitter after extraction and storage. For this reason the navel-orange grower receives little return for the 20 or 25 percent of his crop that is unsuited for the fresh-fruit market. Research conducted over several seasons suggested two possible methods for destroying or removing this bitterness from processed products. One method involves the adsorption of the bitter principle, or its precursor, on activated charcoals, while the other uses a commercial fungal enzyme, or an enzyme complex obtained from tomatoes, to bring about changes in the bitter principle. When either of these methods is prefected for commercial application, the grower will receive a greater return on his crop, and additional fruit will be available to the processor.

F. Some Additional Work Needed

Development of new and improved processing outlets for apples, especially of the Delicious variety. Most apple products manufactured in the Pacific Northwest come from the use of off-grade fruit that is available at less than the cost of production. Even though off-grade apples of the Delicious variety are available at a very low price, their utilization is limited because this variety is unsuited for many processing uses. Although apple production in the Pacific Northwest is primarily a fresh-fruit industry, an extensive processing industry capable, of paying at least the cost of production for its raw material, is considered essential to a stable fresh-apple market. Fundamental information is needed on the factors that influence processing quality of apples to permit improvement in the quality of apple products and the selection of products that can be made satisfactorily from particular varieties.

Selection of new apricot varieties for processing in western Washington. The expanding apricot production of the Pacific Northwest is a fresh fruit industry based on the Wenatchee Morpark variety. This variety is unsuitable for most processing uses, and new improved varieties suitable for canning and freezing are needed to stabilize the fresh-fruit market for apricots. The increasing number of processors canning and freezing other products of this area also would benefit by the addition of a midsummer crop of apricots to occupy an otherwise slack season. An intensive program for the development of new apricot varieties has been undertaken by the Washington State Agricultural Experiment Station, and cooperative studies on the adaptability of these varieties to processing utilization will be a necessary part of this program.

Selection of varieties and improvement of methods for handling and processing Washington-grown freestone peaches. Freestone-peach canning has grown into an important industry in Washington since its beginning about 1937. The product, however, has remained an expensive item because of the considerable hand labor required and inefficiency in production. Better methods for handling, grading, and preparing freestone peaches are needed to facilitate processing, reduce costs, and improve the over-all quality of the canned product. A continuous search is being made by Federal and State agencies for improved freestone-peach varieties. Information on the processing quality of these varieties is an important phase of this work.

Chemistry of the flavonoid constituents of citrus products. Experimental work has indicated that citrus juices contain flavonoid compounds that have the so-called Vitamin P therapeutic activity. Although the literature dealing with this subject is extensive, no one has succeeded in actually identifying the pure substance responsible for this activity. The isolation and identification of the constituents possessing Vitamin P activity has been suggested by members of the citrus industry. The development of a convenient, specific method for the determination of naringin, a bitter flavonoid substance existing in grapefruit peel and juice, is urgently needed by the citrus industry. A precise knowledge of the amounts and nature of all flavonoid substances that may be present in citrus juices would also be of interest to this group.

Pureeing and freezing of tropical and sub-tropical fruits. The freezing preservation of pureed fruits has been so successful that investigations should be carried out on the possibility of applying similar methods for the preparation of purees from little-known fruits grown in southern California. Such fruits as papayas, zapotas, and cherimoyas, are available in limited quantities, but information is needed on their processing and storage to determine whether or not these fruits can be successfully preserved as frozen purees.

Chemistry and processing of avocado products. Preliminary experimental work has indicated that a satisfactory avocado paste can be prepared and preserved by freezing, but after the frozen product is thawed, water tends to separate from the paste. Information is needed on the causes of this separation and means for preventing it. A knowledge of the chemical constituents of fresh avocadoes is also needed to assist in the development of additional methods of preservation.

New food products from waste citrus peel. The principal byproduct from citrus juice manufacture is the residue of pulp and peel, which is customarily dried for stock feed. In the process used for the preparation of this dry feed, large amounts of "press liquor" are obtained, which in turn can be evaporated to molasses for supplementing feeds, or for use by the fermentation industry. In these uses, citrus molasses is in direct competition with forage and grain crops; therefore the profit realized in normal years is too small to make any substantial return on the original fruit. In view of the facts that citrus juices are widely consumed because of their vitamin C content, and that citrus peel is several times richer in this vitamin than is the juice, leaders in the citrus processing industry in California have suggested the possibility of investigating citrus peel as a source for acceptable new food products for use as such or for addition to other foods.

NEW AND IMPROVED USES OF CITRUS PRODUCTS

(BAIC - RM:a-140 - Federal - State - RMA Funds)
(Cooperation with Private Organizations)

A. Purpose and Nature of Current Work

To extend the outlets for citrus fruits through development of new and improved processing methods, by formulating new products, and through improvement of the quality and shelf life of the products. Several fundamental and technological investigations are being conducted to this end. These include development of commercially feasible procedures for the manufacture of high-quality citrus powders; investigations of chemical composition and stability of pigments, aromatic flavor constituents, and other citrus components for the purpose of preparing improved citrus products; improvements in methods for pasteurizing citrus juices to eliminate the development of cooked flavors; determination of the role of enzymes in the deterioration of stored citrus juices or of other citrus products; development of an adequate test for maturity of citrus fruits; improvement of processing procedures for the manufacture of citrus concentrates and investigation of the storage and shipping temperatures required to maintain high quality in such concentrates.

B. Currently Active Line Projects

RM:a-140-1 - Citrus fruit powders. To develop commercially practical procedures for the manufacture and use of dehydrated citrus juices in the form of powders.

RM:a-140-2 - Improvements in the quality of canned citrus juices through a study of the chemistry of the volatile flavoring constituents. To determine what chemical changes take place in the volatile flavoring constituents of processed citrus juices and cause the development of off-flavors and -odors. By chemical identification and estimation of these constituents before and after processing, it may be learned which ones break down or are lost during processing and storage.

RM:a-140-3 - Susceptibility of citrus products to deterioration. Since the deterioration of citrus products in storage is due in part to the action of enzymes that have not been completely destroyed by pasteurization, a study of enzymes in citrus products is being made, with particular reference to those that might produce off-flavors by their activity.

RM:a-140-4 - Organic chemical study of citrus-juice pasteurization. To investigate the chemical changes, under pasteurizing conditions, in individual organic chemical constituents of citrus juices.

RM:a-140-5 - Pilot-plant study of citrus-juice pasteurization. To develop improved means of pasteurizing citrus juices by investigations of the chemistry of the process on a pilot-plant scale.

RM:a-140-6 (C) - Development of a method for producing an edible film in sheet and casing forms (Contract). The object of this project is to develop (through a contract with an appropriate organization) a commercial process for producing a pectin film in sheet and casing forms suitable for packaging certain food products, particularly meats.

RM:a-140-7 - Presence and reactions of sulfur compounds in citrus products. Sulfur compounds frequently have very powerful odors and flavors, and are easily changed to bad smelling substances. Some organic sulfur compounds have been found in orange juice, and their effect on the flavor of citrus products is being studied.

RM:a-140-8 - Changes in the nitrogenous constituents of citrus products which affect flavor, color, aroma, and storage characteristics. Comprehensive study of the nitrogenous constituents of fresh and processed citrus juices is expected to lead to an understanding of the role they play in the formation of off-flavors and -odors. Current work is directed to determine what amino acids are present in citrus juices, and whether any of them are responsible for producing off-flavors or -odors in processed products.

RM:a-140-9 - Improvement in the quality of frozen citrus concentrates. The purpose of this project is to find a practical method for improving the flavor of frozen citrus concentrates by returning to the product certain of the volatile flavoring fractions removed during the evaporation process. The effects of processing methods and storage temperatures on the quality of frozen citrus concentrates will be studied.

RM:a-140-10 - Changes taking place in Florida frozen citrus concentrates stored at different temperatures. To investigate the changes in quality of commercially produced Florida frozen citrus concentrates stored at different temperatures. This investigation is being conducted in cooperation with a commercial packer in Florida.

C. History and Evolution of This Work

Development of improved methods of processing citrus products began about 30 years ago. At that time, much of the processed fruit was canned as juice or in sections, and much of the research work was directed toward developing new and improved canned products. Later, rapid rise in popularity of frozen foods focused attention on this new method of food preservation, and the scope of research was broadened to include the freezing process. Bureau research in these two fields has been largely instrumental in the establishment of the large citrus-canning and citrus-freezing industries which consume an increasing percentage of the huge crop of citrus fruits grown in this country.

During the past 3 years there occurred a spectacular growth of another concentration method--preparation of frozen concentrated orange juices - which was pioneered by the Bureau. Numerous technological problems have arisen in connection with this development, including the problem of more efficient utilization of residual pulp and other waste. The current program is designed to meet these mounting needs of the citrus industry.

D. Funds--Annual Expenditures

Expenditures on this project have been about $64,000, $123,000, and $114,000 for the fiscal years 1948, 1949, and 1950 respectively.

E. Examples of Outstanding Accomplishments

Sulfur compounds in orange juice. Two organic sulfur compounds that may influence odor and flavor have been isolated from orange juice and identified. Together they account for at least three-fourths of all sulfur compounds in orange juice.

An improved deaerator for processing of citrus fruit juices. Bureau food technologists developed an improved machine for removal of oxygen prior to canning of citrus juices. This machine removes more than 90 percent of the dissolved oxygen originally present in the juice, as compared to about 34-percent removal by previously available commercial machines. Several citrus-juice canneries in Florida have adopted this improved machine. Removal of more oxygen resulted in better preservation of flavor and vitamin content during subsequent processing and storage.

Nitrogenous constituents in citrus juices. By means of newly developed analytical techniques, it was demonstrated that about 10 percent of the solid matter of citrus juices consists of six to eight free amino acids. Three have never before been reported as being present in orange juice. The presence of these amino acids enhances the nutritional value of citrus juices. It was also found that the chemical nature of several of these amino acids was such that their breakdown during processing and storage might be the cause of off-flavors.

Pasteurization investigations. The investigations conducted thus far have provided some information on the temperatures required for pasteurization of citrus juices and the variations to be expected in commercial practice. Synthesis of certain bitter compounds that exist in citrus fruits and study of their reactions has furnished basic information needed for the development of accurate methods for measuring such substances and their reaction products in citrus juices. This is an essential step in learning the effect of pasteurization upon the chemical composition of the juices and how to control pasteurization so as to produce canned juices of higher quality and stability.

F. Some Additional Work Needed

Elimination of deteriorative changes in citrus powders. Fundamental investigations are needed on the constituents of citrus powders to find means of preventing such changes as loss of color and development of haylike flavors. The solution of this problem would overcome one of the major obstacles to commercial acceptance of citrus powders. The need for stable citrus powders for the armed forces has been repeatedly mentioned by spokesmen for the Quartermaster Corps and in publications.

Production of citrus concentrates that can be stored without refrigeration. There is urgent need for more fundamental knowledge on the chemical and biochemical changes responsible for the deterioration in flavor of stored citrus-juice products, and for the development of inexpensive products sufficiently stable to be handled at ordinary temperatures. A large potential market exists for products of this type.

Characterization of the volatile flavoring constituents of lemon juice. Frozen concentrated lemonade and lemon juice are rapidly gaining consumer acceptance, and the production of these products is increasing each year. Work is now in progress to identify and learn the properties of the volatile flavoring constituents in orange and grapefruit juices, and to improve frozen orange and grapefruit concentrates by returning to the concentrated juice the volatile constituents lost during evaporation. Similar aid is needed by the producers of lemon juice and lemon concentrates.

Utilization of frost-damaged citrus fruits. At frequent intervals the citrus industry sustains serious economic losses due to freezing, since the frozen fruit is unsuitable for shipment and use as fresh fruit. Most of the damaged fruit is diverted to low-return byproducts such as dry feed, citrus-peel oils, and citrus molasses. Limited amounts are used for the production of some juice products, although it is known that juice from frost damaged fruit is low in quality. Information is needed on the chemical changes in juice from frost-damaged fruit, and how such juice can be utilized to yield the greatest net return to the grower and processor.

Development of a commercial method for the production of improved citrus-peel oils. Citrus-peel oils are produced as byproducts of the citrus processing industry. However, the natural, cold-pressed oils are quite unstable during storage and use. On the other hand, superior "terpeneless" oils can be prepared from cold-pressed oils by removal of limonene, which comprises more than 80 percent of the natural oil. The limonene-free oils are more stable, have a better flavor, and command a higher price. An economical commercial method for producing "terpeneless" citrus-peel oils should be developed.

Stabilization of citrus-peel oils with antioxidants and other means. Citrus-peel oils now being produced commercially are not well stabilized; consequently they may develop off-flavors during storage. Information is needed on the possibility of preventing these chemical changes by adding newly developed antioxidants, "winterizing" (low-temperature treatment), removal of oxygen, or by other means.

DEVELOPMENT OF A METHOD TO MEASURE BITTER PRINCIPLES IN ORANGE JUICE

(BAIC - RM:a 504 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

To find a method for measuring the bitter substances that sometimes form in orange juice, particularly in navel-orange juice. Current work is devoted to testing juice for one of the bitter substances formed which is called limonin, and measuring its quantity.

B. Currently Active Line Projects

RM:a-504-1 - Method to measure the amount of limonin in oranges. The quantity of bitter substance that forms in navel-orange juice is not always the same; it depends upon the rootstock ripeness of the fruit and the weather during the crop year. Thus measurement of the content of bitter substances in juice is in fact a test of the suitability of a particular lot of fruit for processing. There are probably several bitter substances in this juice, but the most important and the commonest one has been identified as a substance called limonin. It is therefore the first to be investigated.

C. History and Evolution of this Work

The fact that bitterness frequently develops in navel-orange juice that is not consumed while fresh, has interfered with the utilization of this variety for canned and frozen juice. The growers of navel oranges estimated that about one-tenth of the crop could not be sold as fresh fruit and was lost because of apparent unsuitability for processing. In the hope of preventing this loss work was started on this project early in the fiscal year 1950 to supplement the existing knowledge regarding the bitter substances that exist or are developed in orange juice.

D. Funds - Annual Expenditure

Expenditures amounted to approximately $8,400 for the fiscal year 1950, the first year for this project.

E. Examples of Outstanding Accomplishments

Since this project was started so recently nothing outstanding has been accomplished thus far.

F. Some Additional Work Needed

Once developed, a convenient and reliable method of assay will be a powerful tool in establishing the mechanism of formation of the bitter substances. Studies should be instituted on methods to stop formation of the bitter substances, so that navel oranges can come into greater commercial use.

CROSS REFERENCES -- UTILIZATION

For additional information especially pertinent to subjects reported on in this chapter, see also:

BAIC-b-9-Chapter 3, microbiological research in freezing of fruits and fruit juices
BAIC-RRL-3-11, Chapter 13, fruit utilization studies of the West
BAIC-RRL-5-3-Chapter 38, utilization of fruits and nut residues
BAIC-RM:a-145, Chapter 38, antibiotics from bananas
BAIC-RM:a-520, Chapter 13, instruments to measure color and moisture of fruits, vegetables, and nuts
BAIC, BAI, BDI-RM:a-307, Chapter 14, fruit byproducts as feed
BHNHE-RM:a-12 & b-1-16, Chapter 29, food utilization and preparation
BHNHE-RM:a-13, Chapter 29, family food consumption
BHNHE-RM:a-345, b-1-17, & b-2-2, Chapter 29, distribution of nutrients in foods and nutritive value.

CONSUMER PREFERENCE RESEARCH (CITRUS FRUITS)

(BAE-BHNHE-OES-RM-c-31-Federal-State-RMA Funds)

(Related consumer preference research by BAE on other commodities is discusse in other commodity chapters. Consumer preference research conducted by BHNH and OES, as well as line projects of BAE involving more than one commodity, are discussed in the general statement on consumer preference research in Chapter 26, "Economics of Marketing").

A. Purpose and Nature of Current Work

To (1) gain information on consumer preferences for citrus fruits and citrus products; and (2) learn the consumption patterns by certain geographic areas and population groups as an aid in expanding outlets for our tremendous production. Frozen citrus products have been introduced and, despite difficult handling problems, have attained considerable acceptance by consumers. The pack of frozen orange-juice concentrate in Florida will approach 50 percent of the crop this season compared with about 10 percent last year. Frozen citrus opens a new market area, the extent of which cannot now be estimated. As the crops are expected to be even larger in the future and competition from other fruits and juices intensified, such information is of great concern to the industry.

B. Currently Active Line Projects

RM:c-31.22 - Consumer preferences among citrus fruits and fruit products
To apply to the nation as a whole the techniques developed in the pilot tests in Louisville and in Nelson County, Ky., and in Houston, Tex. The major objectives are: To ascertain use of citrus products--proportions of homemakers making use of the various products during the year; intensity of use of the products--extent to which homemakers use these products consistently or occasionally; per capita consumption in households using respective products; variation in use of citrus products in terms of (1) year-to-year changes, (2) within-year changes (seasonal variation). To ascertain attitudes and opinions which influence consumers in their use of citrus products; the role of price, quality of product, availability of product, taste, health, etc., in either consistent use, occasional use, or nonuse of specific citrus products; the role of above factors (price, etc.) in (1) year-to-year changes in citrus consumption; (2) seasonal variation in citrus consumption; the manner in which homemakers perceive citrus products within the general class of fruit; attitudes toward (1) various forms of citrus products (sweetened vs unsweetened juices, etc.), (2) various marketing methods (packaged vs loose fresh citrus products, etc.).

RM:c-31.25 - Ability to discern slight differences in processed citrus juices To find out which of several combinations of peel oil, sweetening and acidity can be discerned through the sense of taste by a representative sample of consumers. This is expected to save money and increase the validity of data to be obtained in larger studies, by eliminating any attempt to measure consumer reactions to differences that are too slight to be significant.

C. History and Evolution of This Work

Original research was begun in 1948 and has been expanded and extended because it was the opinion of the RMA Citrus Advisory Committee that its results would prove useful in helping to increase consumption of both fresh and canned citrus. With new acreages coming into bearing, citrus production promises to increase; long-range prospects for profitable returns to growers are not encouraging unless consumption can also be increased. Consumer research of the kinds mentioned is designed to provide information helpful in accomplishing this end. The three studies listed below as completed were preliminary to the present work.

Citrus preferences among household consumers in Louisville and in Nelson Co., Ky. -- this was a pilot or demonstration study consisting of two parallel surveys on a cross-section sample of homemakers in an urban community and in a rural area. This work was preparatory to beginning consumer-preference work on citrus on a national scale. (Agric. Infor. Bulletin No. 2)

Citrus preferences among shoppers in two Houston, Texas supermarkets — a consumer-preference survey of households in a selected area in Houston, Tex., has been integrated with retail-sales data from stores supplying the same area. In addition, consumers' opinions as to the relative value of citrus foods available in fresh and processed forms were checked against laboratory tests. No work has been done in the Southern region which would have a bearing on this project. (In press at Texas A & M College)

Consumers' taste reactions to three experimental blends of orange and grapefruit juice — to test whether consumers could tell the difference between three experimental blends of canned citrus juice and, if so, what were the relative preferences for the blends. This study supplements other work under way both in the Department and in the State colleges. The study was contracted to a private research agency. (Mimeographed report, Dec. 1949)

D. Funds—Annual Expenditures

Consumer preference research on citrus fruits undertaken by BAE during the fiscal year 1950 cost $75,000 from RMA funds.

E. Examples of Accomplishments

Findings in this research have stimulated State experiment stations and citrus commissions to enter into planning conferences with a view to more intensive consumer work on processed citrus products. Also the results of the Louisville, Ky., pilot study led the RMA Citrus Advisory Committee to recommend that similar data be obtained on a national scale. Findings in most of this citrus consumer work have either not yet been published or were published too recently to have resulted in any striking changes in the marketing of these products.

F. Some Additional Work Needed

See general summary of this project in Chapter 26, "Economics of Marketing."

MEASUREMENT OF COSTS AND MARGINS IN MARKETING FARM PRODUCTS--(CITRUS)
(BAE-OES - RM:c-163 - Federal-State - RMA Funds)

(Related work in this project is discussed in other commodity chapters and in Chapter 26, "Economics of Marketing")

A. Purpose and Nature of Current Work

To determine the marketing margins for each service performed between producer and consumer for citrus products and to describe the services rendered at each stage in the marketing system.

B. Currently Active Line Projects

RM:c-163.9 - Marketing margins and price relationships at different levels of trade for selected fruits and vegetables in Denver, Colorado. The purpose of this study is to obtain information on the inter-relationship of prices at various stages in the marketing system, the relation competitively between fresh, canned and frozen concentrated orange juice, to study the pricing policy of retailers, and to measure price spreads.

RM:c-163.11 - Margins involved in marketing citrus fruits. The over-all purpose of this project is to determine the marketing margins for each service performed between producer and consumer for citrus products. In addition, an attempt has been made to describe the marketing services rendered at each stage in the marketing system.

The work under this line project is being expanded to report monthly fluctuations in price spreads for fresh oranges, canned orange juice, and frozen orange juice concentrate. The data for describing these price spreads are being collected at the present time for the 1949-50 season. Monthly reports on price spreads will probably be issued during the 1950-51 season.

C. History and Evolution of This Work

The Department was directed to make studies of this general type by the Research and Marketing Act of 1946, and these specific line projects were given high priority by the Citrus Advisory Committee. Work on citrus fruits in this project was begun in Denver in 1948.

D. Funds--Annual Expenditures

The cost of RMA projects on costs and margins of marketing citrus fruits undertaken by BAE during fiscal year 1950 was $17,900. During the 1949 fiscal year the expenditures totaled $9,100 and during the 1948 fiscal year, $11,400.

E. Examples of Outstanding Accomplishments

Percentage of consumer's dollar returned to growers decreased from 43 percent in 1946 to 17 percent in 1948 for Florida Valencia oranges sold in major northern markets. The eight eastern and midwestern markets studied take one-half of the total Florida crop. The percentage of the consumer's dollar returned to the grower was 19 percent in 1941. The rigidity of marketing charges brought about the reduction in grower returns when retail prices fell precipitously between 1946 and 1948. The study also shows the costs of performing each of the functions necessary in marketing Florida Valencia oranges. The data are presented in a report entitled, "Grove-to-Retail Margins for Florida Valencia Oranges Marketed in Fresh Form in Selected Cities, 1940-48," which is in the process of publication.

F. Additional Work Needed

Comparisons among the costs and margins involved in marketing citrus fruits in different forms, i.e., fresh, canned, single strength juices and frozen concentrated juices. The Citrus Advisory Committee has recommended such research.

Measurement of the costs and margins of citrus fruits marketed through various channels. The purpose of this research would be to determine the more efficient channels through which the fruit may be marketed.

REGIONAL MARKETING RESEARCH ON CITRUS FRUITS
(BAE, PMA, FCA - RM:b-191 - Federal-State - RMA Funds)

(Work conducted in cooperation with states under Regional Projects SM-4, NCM-2, NEM-2, WM-2, WM-3, WM-8, NEM-3, SM-3, see Chapter 39.)

A. Purpose and Nature of Current Work

To (1) measure the costs and margins involved in marketing citrus fruits and relate these margins to the services rendered and volume handled through various marketing channels; through measurement of these costs and margins, to (2) locate the areas of greatest inefficiency in handling to (3) learn the most effective means of increasing the efficiency of packing, processing, and marketing citrus fruits.

Regional marketing research projects on these and other commodities are organized around an area approach; therefore they cut across lines of work being undertaken in several other studies (such as costs and margins in project 163) and supplement the work carried on under those projects. This report covers primarily the work of the Federal agencies, although the States are doing much of the work.

B. Currently Active Line Projects

Marketing desert grapefruit. The purpose is to ascertain the costs and margins involved in marketing desert grapefruit, to estimate the importance of specific markets through which this fruit is sold, to ascertain consumer preferences for desert grapefruit, and to measure statistically the relative importance of factors affecting the demand for it.

RM:b-191.1 - Marketing southern citrus. Costs of performing specific functions in marketing citrus fruits from producing areas in Florida and Texas and marketed in large Eastern markets are studied. Phases of this study include measuring the margins involved in handling citrus fruits in each function, and locating the areas in which costs may be reduced through improvement of inefficient operations. This project is carried on under three subprojects: (1) Analysis of packing and processing costs in Florida and Texas, (2) measurement of margins incurred in wholesale handling of fresh citrus fruits, and (3) measurement of margins involved in retailing fresh and processed citrus products.

C. History and Evolution of This Work

The diminished grower returns on citrus fruits after World War II focused attention of the citrus industry on methods of increasing efficiency of marketing. Studies of costs and margins involved in marketing fresh citrus fruits and citrus products were suggested by growers, shippers, and processors in the producing areas.

The Citrus Fruit Advisory Committee, in 1947, proposed a series of studies on marketing costs, margins, and efficiency, to learn whether it would be possible and feasible to reduce marketing costs and margins through increased marketing efficiency and distribute the gains to growers and consumers.

During the 1948 fiscal year each of the studies outlined above was begun. They have continued each year since, at the packing, processing, wholesale and retail levels.

D. Funds--Annual Expenditures

	BAE	PMA	FCA	Total
1948	7,200	7,400	7,800	22,400
1949	11,900	10,300	10,500	32,700
1950	15,400	5,000	14,800	35,200

These funds do not include those contributed by the cooperating states.

E. Examples of Outstanding Accomplishments

Individual packers and processors have widely used the analysis of processing and packing costs in Florida and Texas, published jointly by the Agricultural Experiment Stations of those States and the Farm Credit Administration. They use it in comparing their costs with the averages shown in these reports. With exception of data on frozen concentrated orange juice available only for the 1949-50 season, these data have been published for each year since the initiation of these projects.

Development of techniques for measuring margins at wholesale and retail was furthered by the methodological studies undertaken in Louisville, Kentucky during the 1948 fiscal year. As a result of these studies it was determined that, due to the joint-cost relationships prevailing in agencies handling a number of commodities, it is not feasible to measure costs of wholesaling or retailing for citrus fruits separately. Therefore, additional work done in later years in Pittsburgh reported only margins involved in wholesaling and retailing citrus fruits. Data for the 1949 fiscal year are now being prepared for publication.

F. Some Additional Work Needed

Intensified and continuing research on costs of processing, packing and marketing fresh citrus and canned single-strength and frozen concentrated juices, is needed because of the rapidly changing marketing picture brought about by the introduction of frozen concentrated juices, in order to measure the effects of new techniques introduced in marketing citrus fruit. The maximum potential value of this type of study can be obtained only if data are collected on a continuing basis so that the effects of different methods of marketing may be discovered in terms of regularities in marketing behavior.

The consumption of citrus fruits and citrus products in institutional trade is an unknown quantity in the over-all pattern of citrus marketing and data is sorely needed to assist in evaluating the importance of these outlets. Data on the volume of marketings and the margins taken by handlers and service agencies selling to the institutional trade will assist growers and shippers in selecting more efficient marketing channels. Such information would give a more comprehensive picture of the over-all pattern of citrus margins.

IMPROVEMENT OF METHODS OF STERILIZING CITRUS FRUITS AGAINST MEXICAN FRUIT FLY AND OTHER INSECTS
(BEPQ - No. RM: C-305 - Federal-Mexican Government - RMA Funds)

A. Purpose and Nature of Current Work

To develop more effective, rapid, and economical methods of freeing citrus fruit from living maggots of the Mexican fruit fly and from other insects, without injury to the fruit. This is essential in order that the fruit may be permitted to move unrestricted in trade channels without danger of transporting insect pests to new localities. The current work concerns studies in Mexico of methods not under investigation on other projects provided for with regular funds (see BEPQ - No. I-a-2, I-a-3, and I-a-4)

B. Currently Active Line Projects

RM: c-305-1 - To determine the feasibility of using various kinds of radiation in freeing citrus and other fruits of infestation by insects. To determine whether a rapid and economical method of freeing citrus fruit of insects is possible by the use of ultrasonics, dielectric heating, accelerated electrons, or other forms of radiation.

RM: c-305-2 - Tests of new fumigants for fruit fly maggots or eggs within fruit. To explore the possibility of fumigating fruit fly infested fruit with newer gasses or materials, so that the fruit may move freely to uninfested areas without carrying live fruit fly maggots or eggs.

RM: c-305-3 - Tests of various formulations to rid lime fruit and foliage of the citrus blackfly. To develop a material highly effective against the blackfly and non-injurious to fruit, which may be used to treat limes and accidentally included leaves moving into the United States, and thus to avoid the hazard of introducing this dangerous pest into the United States.

C. History and Evolution of This Work

In response to an urgent need for quicker, simpler, and more economical means of freeing citrus from infestation by the Mexican fruit fly and other insect pests, allotments have been made from RMA funds beginning with fiscal year 1949 to conduct work on methods not included in the work projects carried on with regular funds. The object of this work has been to facilitate the movement of fruit in commerce without transporting dangerous pests to new localities. The work undertaken with these funds has been in addition to the work with vapor-heat, which is carried on with regular funds. Thus far, intensive work has been done with dips and fumigants for limes moving out of Mexico that might carry the citrus blackfly. The fruit itself is not subject to blackfly attack, but most shipments include large numbers of leaves. It is very difficult to prevent the accidental inclusion of some of these leaves, which may be severely infested. Exploratory work is also being done with various types of radiation --ultrasonics, dielectric heating, and accelerated electrons--to see if something of this kind could be used in a practical way. As there is opportunity, tests will be made of some of the newer fumigants.

Much of the work under this project is being done in cooperation with the Mexican government, at the cooperative laboratory at Mexico City.

D. Funds-- Annual Expenditures

The expenditures for 1949 were about $13,300, and those for 1950 about $14,800.

E. Examples of Outstanding Accomplishments

Treatments being developed for citrus blackfly. Favorable preliminary results have been obtained with dips containing pyrethrum extract and with methyl bromide fumigation to eliminate citrus blackfly from leaves accidentally included with shipments of limes.

F. Some Additional Work Needed

Present lines of work should be intensified and enlarged. No new ones are suggested at this time.

USING FARM COOPERATIVES IN TESTING NEW EQUIPMENT AND DEVELOPING IMPROVED PROCEDURES TO REDUCE SPECIFIC CITRUS MARGINS AND HANDLING COST

(FCA - RM:c 419 - Federal RMA Funds)

A. Purpose and Nature of Current Work

To determine and demonstrate the possibility of increasing efficiency and reducing the cost of harvesting and packing citrus by handling fruit from grove to packinghouse in bulk rather than in field boxes. Under contract with the Florida Agricultural Experiment Station commercial scale equipment for loading citrus in bulk, hauling, coloring or degreening, and transfering to the grading table has been built and operated at the Citrus Experiment Station, Lake Alfred, Florida, during the 1949-50 marketing season. Comparative tests of damage from bruising of fruit handled in bulk with fruit handled in field boxes have been conducted. Plans are underway to install the process in one or more citrus cooperatives in Florida to further test the method under actual commercial packinghouse operations.

B. Currently Active Line Projects

RM:c 419-1. Bulk handling of citrus fruits in Florida. To design and construct equipment for handling citrus fruit in bulk from grove to packinghouse on a commercial scale and to correlate all units of the process into full scale operation. To assist cooperatives and other citrus fruit shippers in adapting the process to their operations and in converting present packinghouse equipment to bulk handling.

C. History and Evolution of This Work

Until the last few marketing seasons citrus fruit in all production areas was harvested, transported, degreened and temporarily stored in field boxes. This method is costly and entails handling the individual boxes of fruit several times before the packing operation. Many packinghouses spend $5,000.00 or more per season for repair and replacement of field boxes alone. Since 1947 a few packinghouses in Arizona have successfully handled desert grapefruit in bulk and have materially reduced harvesting and packing costs. However, in that area, grapefruit is not required to be treated in specially designed degreening rooms and thus can be dumped directly from the field truck onto the production line of the packinghouse. Upon recommendation of the Florida Citrus Research Industry Committee and the RMA Citrus Advisory Committee a project was initiated in 1948 to seek to develop a means of degreening and handling oranges as well as grapefruit in bulk rather than in field boxes. Pilot scale equipment was designed and tested at the Florida Citrus Experiment Station in 1948-49. This work demonstrated the feasibility of bulk handling and the following season a commercial scale bulk handling method was designed, constructed, and tested at the Station.

D. Funds - Annual Expenditures

The funds for this project were as follows: $15,000 in 1949, and $20,000 in 1950, of which a substantial portion was contracted both years.

E. Examples of Outstanding Accomplishments

Bulk handling methods developed. The bulk handling method that has been developed and operated at the Citrus Experiment Station in Lake Alfred, Florida, has demonstrated that citrus fruit can be handled and colored in bulk. It is anticipated, however, that numerous problems will need to be solved before the process will work smoothly under actual production conditions found in a packinghouse handling and selling citrus fruits. If the bulk handling methods should be universally adopted savings to the Florida citrus industry would approximate $2 million annually on the basis of present day utilization and volume.

F. Some Additional Work Needed

Demonstrations needed. Before the bulk handling method can be recommended for industry-wide adoption, it will be necessary to install and operate the process in at least 2 or 3 commercial packinghouses in order to test its performance under continuous plant operation, to work out picking and hauling schedules and rates, to obtain costs of converting present equipment to bulk handling and to determine the effect on the condition of citrus at various levels of distribution. If the method works satisfactorily in Florida it will be tested also in other citrus producing areas.

COORDINATED SELLING OF CITRUS FRUITS IN FLORIDA.
(FCA - RM:b 554 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

The purpose of this project is to develop information and analysis for the use of the Florida citrus industry in evaluating its potentialities for effective group action and in building an industry wide marketing organization and program. The study includes an appraisal of the effectiveness of the marketing system; an analysis of the methods of assembling and selling fresh and processed fruit; a recording of opinions of shippers, processors and buyers regarding the type of central marketing organization the industry needs and the control measures it should employ; a history of overhead marketing agencies in Florida citrus; an analysis of grower-processor relations in Florida, other U. S. growing areas and Canada; and a discussion of the production and price outlook for citrus fruit.

B. Currently Active Line Projects

RM:b 554-1. Coordinated selling of citrus fruits in Florida. To study, analyze and appraise the services of the present citrus marketing organizations in Florida and to determine the practicability of developing a coordinated marketing program on a cooperative basis. To counsel and advise with organizations and industry leaders regarding the utilization of project findings if a coordinated marketing program is found feasible.

C. History and Evolution of This Work

During 1942-45, Florida citrus growers were fortunate in realizing a consistently high rate of return from their crops. However, the cessation of Government purchases of citrus for overseas shipment and the rapidly increasing production of new groves drove prices down below production costs during the 1946-47 marketing season. This situation worsened the following year and there was a strong demand for a program which would improve price and marketing conditions. The type of industry effort generally considered to offer the most effective machinery was a program involving closer coordination between the 400 fresh fruit shippers and 50 processors in selling and merchandising citrus.

Out of this chaotic marketing situation and the interest of the various industry factors in jointly working out their difficulties grew a demand for research that would bring together information bearing on ways and means for building an effective marketing organization with particular reference to central selling. As a result, a request for such a research project was transmitted to the Secretary of Agriculture by a research committee in Florida, composed of growers, processors, packers, and members of the Florida Agricultural Experiment Station. The request was followed up by the Florida members of the RMA Citrus Advisory Committee and a project authorized in June 1949. The Farm Credit Administration was assigned primary responsibility for conducting this research. The Florida Agricultural Experiment Station served in an advisory capacity.

D. Funds - Annual Expenditures

Expenditures during 1949-50, which was the first year of work on the project, amounted to approximately $12,000.

E. Examples of Outstanding Accomplishments

A detailed report on the findings of the study is in the process of preparation. It will be published for the use of the Florida citrus industry in its overall marketing program; for the use of other agricultural industries faced with similar problems; and for reference material for persons interested in citrus marketing.

F. Some Additional Work Needed

Florida growers organized an overhead cooperative organization named Florida Citrus Mutual in mid 1949. This organization conducted a broad marketing program with a fair degree of success during the 1949-50 season. The problems attendant to administering such a large organization are complicated by the multiplicity of sales agencies and the changes which the marketing system is undergoing with the development of frozen concentrated juice and the rapidly increasing production of oranges.

The industry will need additional organizational study and market analysis to enable it to keep pace with its growth and changes until a satisfactory long-time marketing program can be developed.

METHODS OF HANDLING, TRANSPORTATION AND STORAGE OF CITRUS AND OTHER SUBTROPICAL FRUITS.

(BPISAE b-8-2 - Federal - State - Regular Funds)

A. Purpose and Nature of Current Work

To (1) develop means of evaluating maturity, to investigate methods of harvesting, handling, packing, precooling, storing, and transporting citrus and other subtropical fruits, and (2) develop the most efficient and economical practices that can be used commercially to deliver fruit of the best quality in prime condition to the consumer.

B. Currently Active Line Projects

b-8-2-1 - Seasonal changes in Florida citrus fruit. To determine the seasonal changes in composition and quality of citrus as affected by soils, root stocks, weather, sprays and other factors and to correlate the composition and quality with market suitability.

b-8-2-2 - Precooling and transportation of citrus fruits. To determine the most effective and economical methods of precooling citrus and refrigerating it in transit to reduce spoilage and deliver prime quality fruit to the consumer.

b-8-2-3 - Storage of citrus fruit to maintain quality and prevent spoilage. To determine the storage life and quality of citrus fruit stored in the growing area or at the market as affected by storage temperature, growing season, variety, maturity, field sprays, disinfectant treatments, and types of packages.

b-8-2-4 - Suitability of new containers for citrus fruits. To study the effect of different types of packages, such as diphenyl-treated and non-treated multiwall kraft bags, mesh bags, and various kinds of wooden and cardboard boxes, on mechanical damage and spoilage of citrus in transit and at the market.

b-8-2-5 - Cause and prevention of "burnt stems" and premature "aging" in oranges that restrict storage life and detract from market quality. Studies are conducted to determine the influence of growing and handling practices on premature aging conditions of oranges.

b-8-2-6 - Degreening of citrus fruit, physiology of rind pigments. To determine the effect of temperature, field spray treatments, and other factors on degreening; to study the physiology of natural and induced changes in the rind pigments; and to investigate the possible use of other gasses or mixtures of gasses with ethylene to accelerate the degreening process and retard decay.

b-8-2-7 - Prevention of shrinkage of citrus fruit during storage or in the process of marketing, studies on waxing and polishing methods. To determine the effect of different wax preparations on wilting, aging, decay, and flavor of treated fruit.

b-8-2-8 - Handling, transportation and storage of dates in California and Arizona. To determine the effect of relative humidity and temperature on storage life and quality, and to develop processes for softening to improve the quality of dry dates.

b-8-2-10 - Seasonal changes in California and Arizona citrus fruit. See statement under b-8-2-1.

C. History and Evolution of This Work

Studies on the handling, storage, and transportation of Florida and California citrus fruits were undertaken soon after the Bureau of Plant Industry was organized in 1901. Application of the results of these early studies contributed greatly to the development of the citrus industry. The early studies were concerned primarily with the reduction in decay by more careful harvesting and handling practices and refrigeration. These studies have been continued, and in addition physiological studies on factors that affect appearance, flavor, and nutritional composition have been undertaken.

D. Funds--Annual Expenditures

Allotments ranged from $5000 to $15,000 from 1901 to 1920, increased to about $44,000 in 1934 and 1935 and, as citrus fruits assumed greater importance in the agricultural economy, expenditures for research work increased to $51,000 in 1940, $58,000 in 1944, $101,540 in 1949 and $96,410 in 1950.

E. Examples of Outstanding Accomplishments

Control of Decay Developed. The early investigations demonstrated that excessive decay could be prevented by careful harvesting, handling, and packing house practices and refrigeration. Application of these basic principles removed the chief hazard in long-distance shipments of citrus fruits and made possible the development of the citrus industry to its present proportions.

Savings in refrigeration in transit costs. Transportation tests have demonstrated that considerable savings in refrigeration costs can be made without sacrificing protection by using modified refrigeration services calling for less than the full number of icings given under the more costly standard refrigeration service which was formerly used. These savings amount to as much as $60 per car and have resulted in saving many millions of dollars to the citrus industry. The California Fruit Growers Exchange in 1949 stated that $750,000 had been saved in 2 years by shipping oranges in winter months under "controlled ventilation" instead of in iced cars, utilizing cold outside air for refrigeration. This method was worked out and tested by Department of Agriculture representatives.

Storage Manual Developed. Results of storage studies have been summarized in Circular 278 (see table 3, page 15 and pages 21-25) which provides information on the optimum temperature, humidity, and other storage conditions to give the longest storage life and maintain the best quality.

Improved quality. Maturity investigations in Florida, California, and Arizona have yielded important information on seasonal changes in the solids-acid ratio, volume of juice, and flavor of different varieties and types of citrus fruit. The results of these studies were used in the preparation of the 1949 Florida Citrus Code which, according to leaders in the citrus industry, was responsible for bringing better quality fruit to the market and improving the demand for Florida citrus. As a result of the increased demand, before early January when the freeze removed competitive California fruit from the market, Florida shippers had already received $8,000,000 more for their crop than they did in 1948.

Storage of citrus. Tests in Florida, Texas, and New York have demonstrated that oranges and grapefruit can be stored successfully either in the producing area or at the terminal market, and the marketing season is thus extended. In 1949 two car loads of Florida oranges after storage for 12 weeks in New York showed little decay and practically no pitting or aging and sold for $2.00 to $3.25 more per box than when stored.

Improved quality in dates. A method has been developed to improve the quality of dry dates by infiltrating them with an alkaline sulfite solution under pressure to soften the fruit and correct acidity.

F. Some Additional Work Needed

Performance of refrigerator cars. Important changes and improvements are still being made in refrigerator cars and equipment. Additional tests are needed to evaluate performance of the new equipment for different commodities.

Determine best and cheapest protective services for various kinds of citrus and other subtropical fruits. Only part of the subtropical fruits have been extensively studied so far. Further information is urgently needed on other kinds and from various production areas.

Truck transportation. There is a growing demand for information on truck transportation. The performance of present equipment needs to be determined and the design and equipment needs improvement in order to provide adequate protection.

Transportation of frozen foods. The rapid development of the frozen citrus concentrate industry has made it essential to determine whether or not present refrigerator car and equipment provide low enough temperatures and to test new equipment. The work has been started.

INFLUENCE OF FROZEN CONCENTRATED CITRUS JUICES ON THE PRICE STRUCTURE AND MARKETING PRACTICES FOR CANNED CITRUS JUICES AND FRESH CITRUS FRUITS

(PMA-RM-c-549 - Federal - RMA Funds)

A. Purpose and Nature of Current Work

To assist citrus fruit producers in channeling fruit into thos marketing outlets that will maximize their returns and to assi fresh fruit shippers and processors of canned and frozen co trated juices in developing merchandising plans that will r in the most orderly marketing of the citrus fruit crops. Pres work is aimed at determining the influence of the rapidly expa production of frozen concentrated citrus juices upon the handl and marketing of fresh citrus fruit and canned citrus juices a measuring the economic effects of this new development upon the citrus fruit industry.

B. Currently Active Line Projects

RM-c-549-1 - Determining effect of frozen concentrated citrus ju on price structure, grower returns, and marketing practices for fresh citrus fruit and canned citrus juices. To collect data on production, distribution, and consumption of frozen concentrated citrus juices, including data on costs and returns to growers; to develop information on the flow of citrus fruit in all forms of u ization from the grower to ultimate consumer; and to analyze the effect of changes in utilization upon existing facilities.

C. History and Evolution of This Work

A process of manufacturing frozen concentrated orange juice was pe fected and put into commercial operation in the 1945-46 marketing season. The product enjoyed immediate consumer acceptance. From the initial season's production of 226,000 gallons, the output was expanded to more than 11,000,000 gallons in 1948-49, and during the current season (1949-50) production is expected to exceed 25,000,0 gallons.

Aside from technical information relating to the production of froze concentrated citrus juice, plus fairly complete data on volume of production, little has been known of the potential economic effect o frozen concentrated juices upon the citrus industry. It was readily apparent that the channeling of large volumes of fruit into the manu facture of frozen concentrated juice would have a marked effect upon all sectors of the citrus industry. This project was initiated in order to improve the economic information relating to frozen concentrated citrus juices and to evaluate the effect of these produc upon returns to growers, upon the marketing framework, and upon th utilization of citrus fruits, particularly oranges.

D. Funds--Annual Expenditures

1950 expenditures were $4,500.

ples of Outstanding Accomplishments

smuch as work under this project was initiated late in fiscal year 0, there are no outstanding accomplishments to report. The task data collection is now going on, but analyses of the data and the velopment of significant results have not yet been made.

ome Additional Work Needed

nalyses contemplated under this project have been hampered and will ntinue to be hampered by the lack of adequate information on various ses of the production and distribution of frozen concentrated citrus juices. Data available to researchers, for example, are not complete on costs of processing these products in all of the major producing areas.

Moreover, there are considerable gaps in the information covering movement of these products at each stage from processor to consumer. Institutional outlets such as restaurants, hotels, and hospitals, for example, are known to be using considerable quantities of frozen concentrated juices. However, there are no reliable data at present on the volume of such utilization.